

INTERMITTENT SCHEDULES OF REINFORCEMENT AND PUNISHMENT:
IMPLICATIONS FOR THE TREATMENT OF SEVERE BEHAVIOR DISORDERS
IN INDIVIDUALS WITH DEVELOPMENTAL DISABILITIES

By

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Abstract of Dissertation Presented to the Graduate School
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Results of numerous studies indicate that extinction and punishment are effective in treating a variety of severe behavior disorders, including self-injury and aggression. In the natural environment, however, the history of reinforcement that precedes treatment with extinction and the consistency of punishment contingencies may not resemble those in studies examining the utility of these treatment procedures. Staff generally do not deliver reinforcement and punishment following every instance of the problem behavior, and basic research findings suggest that these intermittent contingencies could have important implications for treatment efficacy. The current series of studies examined the effects of intermittent reinforcement and punishment schedules on the treatment of self-injury and related behavior disorders. Subjects whose behavior was maintained by social reinforcement were exposed to baseline conditions with continuous and intermittent

reinforcement schedules, and their performance during subsequent extinction was compared. In a separate study, a procedure designed to increase the efficacy of intermittent punishment was examined with subjects whose behavior was not maintained by social reinforcement. Delivery of punishment was leaned gradually while attempting to maintain low levels of self-injury. Data are presented indicating that these intermittent contingencies can have complex effects on responding during treatment. Various strategies for the use of intermittent schedules in the natural environment are discussed, as are potential refinements and extensions of these investigations.

INTRODUCTION

The current series of studies examined the effects of intermittent reinforcement and punishment on the treatment of self-injury and related behavior disorders in individuals with developmental disabilities. After identifying the reinforcement contingencies maintaining problem behavior, the effects of continuous and intermittent reinforcement schedules during subsequent extinction were compared for subjects whose behavior was maintained by social reinforcement. In a separate study, the effects of intermittent punishment schedules on treatment with timeout or contingent restraint were examined for subjects whose problem behavior was not maintained by social reinforcement.

Assessment and Treatment of Severe Behavior Disorders

Research findings during the past 30 years have demonstrated that many problem behaviors exhibited by individuals with developmental disabilities are learned responses and, as such, are treated most effectively with procedures based on principles of operant conditioning. Severe behavior disorders such as self-injury and aggression have been treated with a variety of procedures, including extinction, differential reinforcement, and punishment. In recent years, studies have focused increasingly on the use of functional analyses to identify the specific sources of reinforcement that maintain problem behavior, and research findings indicate that treatments based on the outcome of such assessments are more effective in reducing problem behavior than those selected arbitrarily (e.g., Iwata, Pace, Dorsey et al., 1994; Iwata, Pace, Cowdery, & Miltenberger, 1994; Repp, Felce, & Barton, 1988).

During the past ten years, numerous studies have concentrated on the development and refinement of functional assessment methodologies (see Iwata, Vollmer, & Zarcone, 1990, and Mace, Lalli, & Lalli, 1991, for recent reviews). The experimental (functional) analysis, which involves direct and systematic manipulation of potential maintaining variables, has been used most often. Compared to other assessment methods, the functional analysis is considered superior for identifying causal relationships, and the utility of this approach has been well established with a variety of behavior disorders, including self-injury (Day, Rea, Schussler, Larsen, & Johnson, 1988; Iwata, Pace, Dorsey et al., 1994; Steege et al., 1989); stereotypy (Adams, Tallon, & Stangl, 1980; Sturmey, Carlsen, Crisp, & Newton, 1988), aggression (Mace, Page, Ivancic, & O'Brien, 1986; Slifer, Ivancic, Parrish, Page, & Burgio, 1986), and disruption (Carr & Durand, 1985).

Before conducting a functional analysis, putative variables may be identified via other assessment methods, such as interviews or descriptive (correlational) analyses. However, most studies on the functional analysis of behavior have employed a general assessment approach developed by Iwata, Dorsey, Slifer, Bauman, and Richman (1982), which tests several variables potentially relevant to the target behavior. The experimental conditions of the functional analysis described by Iwata et al. (1982) are designed to examine the relative influence of social-positive reinforcement (in the form of attention), social-negative reinforcement (in the form of escape from instructions), and automatic reinforcement on rates of problem behavior.

Research on the functional analysis of behavior has isolated a number of contingencies that maintain severe behavior disorders. These reinforcing consequences can be mediated through the actions of others (i.e., "social" consequences) or produced directly by the behavior (i.e., "automatic" consequences). Contingencies that maintain maladaptive behavior include access to attention (e.g., Mace et al., 1986), play materials

(e.g., Day et al., 1988), and response-produced stimulation (e.g., Rincover, Cook, Peoples, & Packard, 1979), as well as escape from instructions (e.g., Iwata, Pace, Kalsher, Cowdery, & Cataldo, 1990), social interaction (e.g., Taylor & Carr, 1992), and ambient stimulation (e.g., Iwata, Pace, Dorsey et al., 1994).

Treatment programs based on results of functional analyses can take a variety of forms (see Iwata, Vollmer, & Zarcone, 1990, and Mace et al., 1991, for reviews). For example, practitioners can implement procedures to alter antecedent events that occasion behavior problems (e.g., Weeks & Gaylord-Ross, 1981), eliminate access to maintaining reinforcers through extinction (e.g., Iwata, Pace, Cowdery, et al., 1994), or provide those reinforcers contingent on alternative behavior (e.g., Carr & Durand, 1985). Particularly relevant to the current study is the fact that extinction often may be a crucial component of effective treatment (cf. Fisher et al., 1993; Mazaleski, Iwata, Vollmer, Zarcone, & Smith, 1993; Wacker et al., 1990; Zarcone, Iwata, Smith, Mazaleski, & Lerman, 1994).

Extinction involves terminating the reinforcement contingency that maintains a response, which results in a reduction in the behavior's occurrence over time. Several procedural variations of extinction have been examined in the literature. The most common, extinction of responding maintained by positive reinforcement (e.g., access to attention or leisure materials), usually involves withholding the specific reinforcing stimulus. For example, extinction might be implemented by failing to provide attention following occurrences of the target response (e.g., France & Hudson, 1990). Extinction of responding maintained by negative reinforcement (e.g., escape from or avoidance of instructional activities) usually involves continued presentation of the aversive stimulus despite occurrences of the behavior, a procedure often called "escape extinction." For example, extinction might be implemented by continuing the instructional activity

(i.e., failing to provide escape) contingent on occurrences of the target behavior (e.g., Iwata, Pace et al., 1990).

Applied researchers also have developed extinction techniques for behavior maintained by nonsocial (automatic) reinforcement. In some cases, behavior appears to produce its own maintaining consequences directly, which can serve as either positive reinforcement (e.g., “pleasurable” tactile or auditory stimulation) or negative reinforcement (e.g., attenuation of “painful” or aversive stimulation). Extinction of behavior maintained by automatic reinforcement, often called “sensory extinction,” includes a variety of techniques designed to attenuate or eliminate the hypothesized reinforcing stimuli that follow occurrences of the target behavior. Procedural variations of sensory extinction depend on the type stimuli (e.g., auditory, visual, tactile) maintaining the response. For example, self-injurious behavior (SIB), such as head hitting, arm biting, and hand mouthing, sometimes appears to be maintained by response-produced tactile stimulation. Sensory extinction has been implemented in these cases by placing equipment (e.g., helmets, gloves) on the individual to block or attenuate the stimulation (e.g., Dorsey, Iwata, Reid, & Davis, 1982; Luiselli, 1988).

Results of numerous studies have shown that extinction can produce robust treatment effects when the procedure is implemented as the sole intervention (e.g., Iwata, Pace, Cowdery et al., 1994) or in combination with alternative procedures, such as differential reinforcement of other behavior or DRO (Vollmer, Iwata, Zarcone, Smith, & Mazaleski, 1993) and differential reinforcement of alternative behavior or DRA (Lalli, Browder, Mace, & Brown, 1993). In fact, the efficacy of such procedures has led some authors to suggest that the current functional analysis technology has eliminated the need for restrictive interventions such as punishment (e.g., Donnellan & LaVigna, 1990).

In a recent paper addressing this issue, however, Vollmer and Iwata (1993) discussed several conditions under which treatment based on the results of functional analyses would not necessarily preclude the use of punishment. One condition particularly

relevant to the current experiments involves the treatment of behavior maintained by automatic reinforcement. In this situation, treatment options may be somewhat limited. Unlike extinction of behavior maintained by social reinforcement, sensory extinction is particularly complex because it can be difficult to identify or withhold the specific reinforcing stimuli produced by the behavior. When these reinforcers cannot be eliminated, the efficacy of other (nonaversive) interventions, such as DRO and DRA, will depend on the identification of alternative sources of stimulation that successfully compete with, or substitute for, the maintaining reinforcer.

Compared to reinforcement-based treatments, punishment generally may be more successful in “overriding” the variables that maintain problem behavior (Paisey, Whitney, & Hislop, 1990; Vollmer & Iwata, 1993). Punishment procedures, including timeout from positive reinforcement and the delivery of aversive stimulation (e.g., electric shock, loud noise, water mist, certain tastes and smells), have effectively reduced a variety of severe behavior disorders maintained by unknown sources of reinforcement (see Axelrod & Apsche, 1983, Matson & DiLorenzo, 1984, and Vollmer, 1994, for reviews). Such procedures may in fact be the “most reliable treatments in the absence of a conclusive functional analysis” (Vollmer, 1994, p. 201).

Results of studies on extinction and punishment suggest that these procedures would be effective in treating problem behavior in applied settings such as schools and residential facilities. However, as discussed in the next section, the efficacy of these procedures may depend on the extent to which certain conditions operating in the natural environment are similar to those found in the research setting.

Implications of Research Findings on Extinction and Punishment for Treatment Programs in Applied Settings

It is generally assumed that the robust treatment effects demonstrated in research on extinction and punishment can be replicated in applied settings when teachers or caregivers attempt to reduce problem behavior. In many cases, however, treatment efficacy may be compromised because the manner in which some contingencies are implemented in the experimental setting is significantly different from those in the natural environment.

In clinical research on extinction, it is common practice to expose subjects to a baseline period during which every occurrence of the target behavior is followed by reinforcement (the consequence that will be later withheld during extinction). In the natural environment, however, reinforcement rarely follows every instance of the response. For example, staff do not typically attend to each occurrence of inappropriate behavior, or they may be unwilling to allow escape from certain demands (e.g., “Get dressed.”). In a similar manner, most studies on punishment involve consistent delivery of consequences even though staff often fail to implement punishment contingencies following every instance of the inappropriate behavior .

Thus, in the natural environment, the history of reinforcement preceding treatment with extinction or the consistency with which punishment is implemented may not resemble that found in studies examining the utility of these treatment procedures. Consequences often are delivered intermittently in the natural environment, and results of basic research suggest that these patterns of contingencies (called “intermittent schedules of reinforcement or punishment”) may influence treatment efficacy. The next section describes these schedules of reinforcement and punishment in greater detail, thus setting a framework for a review of studies on intermittent schedules, as well as for the current series of studies.

Reinforcement and Punishment Schedules

Schedules of reinforcement and punishment are rules specifying the probability that a specific occurrence of a response will be followed by reinforcement or punishment.

Under a continuous schedule, every occurrence of the response produces the reinforcer or punisher. By contrast, intermittent (INT) schedules are those in which only some instances of the response are followed by the consequence. A variety of INT schedules of reinforcement and punishment have been examined in basic studies (e.g., Azrin, Holz & Hake, 1963; Ferster & Skinner, 1957; Filby & Appel, 1966).

For example, delivery of consequences can be based on the number of responses that occur (called “ratio schedules”) or on the passage of time (usually since the last reinforced or punished response, called “interval schedules”). The ratio or interval requirement for delivery of a reinforcer/punisher can remain constant (i.e., “fixed”) or it can vary around some average value (i.e., “variable”). Thus, consequences may be delivered following a constant number of responses (“fixed ratio” or FR), after a constant amount of time has elapsed (“fixed interval” or FI), following a variable number of responses (“variable ratio” or VR), or after a variable amount of time has elapsed (“variable interval” or VI). When behavior maintained by reinforcement is exposed to punishment, different schedules can be specified for the two contingencies. For example, a behavior maintained on an FI schedule of reinforcement may be punished on a VR schedule.

Problem behavior can be exposed to one or more of these INT schedules in the natural environment (although variable schedules are probably more common than fixed schedules). For example, staff may withhold consequences until the individual’s behavior becomes “too bad to ignore” or “bad enough to warrant intervention.” In this situation, patterns of reinforcement or punishment delivery may approximate ratio schedules. On the other hand, some caregivers may reliably provide consequences for an individual’s target behavior, but they do not observe the individual continuously

throughout the day. In this case, responding may produce a consequence only after a period of time has elapsed (i.e., the interval during which the individual is unobserved), a pattern that may approximate interval schedules.

Although these examples describe INT schedules of social consequences, similar patterns could be in effect when the problem behavior produces its own reinforcing or punishing stimuli (i.e., automatic consequences). In some cases, for example, the occurrence of a certain number of responses may be necessary to produce the consequence (i.e., the effects of a response may be cumulative). Compared to schedules of social consequences, however, patterns of automatic reinforcement or punishment are extremely difficult to identify and manipulate. Thus, studies examining INT schedules of reinforcement and punishment have focused primarily on social consequences. Results of this research and their implications for the treatment of problem behavior in applied settings are discussed in the next two sections.

Intermittent Schedules of Reinforcement: The Partial-Reinforcement-Extinction Effect¹

Results of numerous basic studies with humans and nonhumans indicate that exposure to INT, or partial, schedules of reinforcement can increase resistance to extinction, a phenomenon that has been termed the “partial-reinforcement-extinction effect” (see Kimble, 1961, and Mackintosh, 1974, for reviews). Resistance to extinction (i.e., the extent to which responding persists in the absence of reinforcement) has been measured by calculating response rate (e.g., Cowen & Walters, 1963), number of responses (e.g., Bijou, 1958; Hearst, 1961), or amount of time to meet a prespecified extinction criterion such as no responses for 5 min. (e.g., Perin, 1942). Using one or

¹This review is limited to studies examining the effects of intermittent reinforcement on free-operant responses. Results of these studies may be more relevant to the current experiment than those of studies examining discrete-trial procedures because problem behaviors usually are free-operant responses (i.e., they can be displayed at any time).

more of these measures, basic researchers have demonstrated the partial-reinforcement-extinction effect (PREE) with a variety of subjects, responses, and reinforcement schedules.

As a result, the PREE often is considered “one of the fundamental rules governing the application of learning principles to practical problems” (Pittenger & Pavlik, 1988, p. 2). In particular, results of studies on the PREE suggest that problem behaviors may be difficult to treat with extinction if they have been maintained on INT rather than continuous (FR-1) schedules. Some authors have even suggested that, due to potential difficulties generated by the PREE, extinction should not be used as treatment for severe behavior disorders (e.g., LaVigna & Donnellan, 1986). Thus, it is somewhat surprising that no applied studies have examined the clinical significance of the PREE with problem behavior, and that only a few studies have investigated the effects of INT schedules on other types of responses.

Kazdin and Polster (1973), who reinforced the social interactions of two men diagnosed with mild retardation during three daily break periods at a sheltered workshop, compared the effects of two reinforcement schedules on response maintenance during extinction. Reinforcement conditions were alternated with extinction conditions within a reversal design. Initially, both subjects received tokens immediately following each break period (“continuous reinforcement”) for conversing with peers. They were then exposed to extinction for three weeks, and the social interactions of both subjects decreased to near zero levels by the second week. Following extinction, one subject received tokens on the continuous schedule for conversing with peers, while the other subject received tokens after either one or two of the three break periods (“intermittent reinforcement”). Both subjects then were exposed to extinction for five weeks. The subject who had received tokens on the continuous schedule exhibited few social interactions by the second week of extinction, whereas the subject who had received

tokens on the INT schedule showed no reduction in behavior across the five weeks of extinction. Although these results provide one of the few demonstrations of the PREE in applied research, the effect of INT reinforcement may have been partially a function of reinforcement delay, another variable that was included in the procedure (i.e., the subjects received reinforcement after the break period rather than immediately following each interaction). When combined with INT schedules, reinforcement delay can enhance the PREE (cf. Peterson, 1956). In addition, results of this between-subject comparison may simply reflect different extinction rates for the two subjects.

Results of a study by Koegel and Rincover (1977) also suggested that INT schedules can facilitate behavioral maintenance. In the study's first experiment, the appropriate behavior of two children diagnosed with autism generalized to settings unassociated with the treatment contingencies but failed to maintain in these settings in the absence of reinforcement. Consequently, in a separate experiment, the authors manipulated the reinforcement schedule in the training setting to examine its effect on response maintenance in the nontraining setting with four children diagnosed with autism. Results showed that a relatively thin reinforcement schedule, in which every fifth instance of appropriate behavior in the training setting received reinforcement (i.e., FR 5), was associated with continued responding in the nontraining setting with no apparent decrements for up to 500 trials, whereas FR-1 or FR-2 schedules were associated with fairly rapid decreases in behavior in the nontraining setting. However, three of the children were exposed to just one reinforcement schedule (FR 1, FR 2, or FR 5); thus, results of this between-subject comparison may simply reflect different extinction rates for the three subjects. Although the fourth child was exposed to two reinforcement schedules (FR 2 and FR 5), each was paired with a different response, and the results could reflect different extinction rates for the two types of behavior.

Finally, Baer, Blount, Detrich, and Stokes (1987) investigated the effects of INT schedules on the maintenance of correspondence between verbal and nonverbal nutritious

snack choices in a day-care setting. Maintenance of correspondence following both FR-1 and INT schedules was compared for one of the three subjects within a reversal design. (The other two subjects were exposed to extinction after INT only.) First, the subject received reinforcement (e.g., hugs, stickers) for verbalizing healthy food choices prior to the daily snack period, a procedure that resulted in little change in the amount of nutritious items actually selected during snack time. During the next phase, the subject received reinforcement only if these verbalizations matched the items chosen during snack time (reinforcement of correspondence), and results demonstrated a large increase in the number of healthy food items selected. When the experimenters reversed to the initial condition (reinforcement of verbalizations), the amount of nutritious snack choices gradually decreased to near zero levels. Reinforcement for verbal/nonverbal correspondence then was reinstated, and the schedule was gradually thinned from 100% to 33% (i.e., reinforcement was delivered on 33% of the days) prior to the second maintenance phase, during which the subject was asked to verbalize food choices but received no reinforcement for either verbal or nonverbal choices. Following INT, the subject's appropriate snack choice behavior maintained for 17 experimental sessions conducted across a 7-week period.

However, two factors other than the PREE may be responsible for the findings of Baer et al. (1987). First, a larger number of reinforcers was delivered prior to the second maintenance phase (i.e., when reinforcement was reinstated and gradually leaned), possibly enhancing resistance to extinction. Second, procedures implemented during the two maintenance phases were different and could account for the varying levels of resistance. During the first maintenance phase (following the FR-1 schedule), reinforcement was delivered prior to snack time for correct verbalizations, whereas during the second maintenance phase (following the INT schedule), no reinforcement was delivered for either verbal or nonverbal snack choices. In the conditions immediately

preceding both maintenance phases, however, reinforcement was delivered after the snack period for verbal/nonverbal correspondence. As a result, the first maintenance phase contained a salient stimulus (reinforcer delivery for pre-snack verbalizations) that was absent from both the reinforcement and second maintenance conditions.

Accordingly, the subject's behavior may have maintained for a longer period of time during the second maintenance phase because the transition from reinforcement of correspondence to extinction was less obvious (i.e., more difficult to discriminate) than the transition from reinforcement to the first maintenance phase. In a similar study, Baer, Williams, Osnes, and Stokes (1984) obtained maintenance of verbal/nonverbal correspondence by simply delaying the reinforcement for verbalizations, and the authors concluded that delivery of the reinforcer immediately following verbalizations functioned to signal the termination of reinforcement for correspondence (i.e., extinction).

Although results of these studies replicate those of basic research demonstrating that INT schedules can increase resistance to extinction, each contains limitations that prevent clear interpretation of the findings in terms of this variable. Thus, further studies should investigate the clinical significance of the PREE, particularly with inappropriate behavior.

Additional applied research on the PREE also should be conducted because the relationship between reinforcement intermittency and resistance to extinction is actually somewhat complex. A brief discussion of several complications that have emerged in the basic literature and their relevance to applied research on the PREE is in order.

Most basic studies on the PREE, using a between-subject design, exposed separate groups of subjects to different reinforcement schedules and, after averaging the responses of individual subjects within each group, compared the performance of the different groups during extinction. However, this design may not be practical in applied research because the high-degree of intersubject variability common among humans (who generally have varied and extensive reinforcement histories prior to the study) would

require the use of large subject pools. Further, results of between-group comparisons may not be directly relevant to the behavior of individuals (Sidman, 1960). For these reasons, applied studies on the PREE must use experimental designs that permit within-subject comparisons of responding during extinction.

In the basic laboratory, however, many attempts to replicate the effect using a within- rather than a between-subject design have failed (e.g., Adams, Nemeth, & Pavlik, 1982; Cohen, Riley, & Weigle, 1993; Pavlik, Carlton, Lehr, & Hendrickson, 1967; Warren & Brown, 1943). In some of these studies, subjects were exposed to different reinforcement schedules alternated with extinction in a reversal design. More commonly, subjects were exposed to rapidly alternating reinforcement conditions, each paired with a distinct stimulus. For this design (i.e., the multielement or multiple-schedule design), rapid alternation of the stimuli continued during extinction, and responding in the presence of the different stimuli was compared to determine the effects of the different reinforcement schedules. Although most studies using the reversal design have obtained the PREE (e.g., Cohen et al., 1993; Wertheim & Singer, 1964), studies using the multielement or multiple-schedule design often have reported a “reversed PREE” (i.e., greater resistance following FR 1 than INT; e.g., Adams et al., 1982; Flora & Pavlik, 1990; Mellgren & Elsmore, 1991) in addition to the conventional PREE (e.g., Hearst, 1961; Pavlik & Flora, 1993).

In several papers, Nevin (1974, 1988, 1992) suggested that the usual finding for both within- and between-subject comparisons is the reversed PREE, particularly if the data are transformed to adjust for differences in response rates associated with different schedules of reinforcement. Rate of responding under INT schedules is generally much higher than responding under FR-1 schedules. As such, Nevin has argued that traditional measures of resistance, including response rate, number of responses, and time to meet an extinction criterion, should not be compared following baselines with

INT and FR-1 schedules because the terminal acquisition performances are not equitable. Instead, rate of decrease in responding (i.e., slopes of extinction curves) should be examined, and data on the PREE should be expressed as a proportion of the response rate during baseline or during the initial extinction session(s).

Nevin (1988) used these measures of resistance to reanalyze data from several previous studies on the PREE and found that responding after the FR-1 baseline was consistently more resistant to extinction than responding after the INT baseline. He suggested that rate of reinforcement rather than reinforcement intermittency actually determines resistance to extinction. Thus, exposure to an FR-1 schedule, which often is associated with a higher rate of reinforcement than INT schedules, should generally increase resistance to extinction in the natural environment. Nevertheless, it also could be argued that the traditional measures of resistance, such as number of responses and time to reach an extinction criterion, are more relevant to applied problems than the proportion of baseline (or initial extinction session) measure (Pavlik & Flora, 1993). For example, practitioners treating dangerous behavior generally would be most concerned about the total number of responses exhibited during the course of extinction.

Applied studies on the PREE must include consideration of the most appropriate measures of resistance and experimental designs. As noted above, applied studies probably should use within-subject designs, such as the reversal and multielement designs. Nevertheless, each design contains potential limitations, which might be attenuated with certain refinements in methodology.

Although the reversal design permits a direct comparison of responding during extinction following exposure to each type of reinforcement schedule, results may be confounded by sequence effects. The reversal design necessarily exposes the subject to a history of reinforcement and extinction, which can influence the outcome in two ways. First, repeated exposure to reinforcement might alter responding during subsequent extinction phases. For example, resistance to extinction might increase as the subject is

exposed to an increasing number of reinforcers (cf. Perin, 1942). Although order effects (i.e., history with specific conditions that influence the outcome) could be identified by varying the order of reinforcement conditions across subjects, previous exposure to reinforcement per se cannot be eliminated with this design. Second, repeated exposure to extinction might alter responding during subsequent extinction conditions. In some cases, for example, resistance to extinction will decline across successive extinction phases (cf. Clark & Taylor, 1960).

Although the multielement, or multiple-schedule, design minimizes sequence effects, it may be limited by interaction effects across conditions during either reinforcement or extinction phases, a problem that has been encountered in basic studies on extinction (e.g., Amsel, Rashotte, & Mackinnon, 1966; Rashotte, Ross, & Amsel, 1968). For example, conditions presented during one component of the multielement design could influence responding in a different component, obscuring any differences in the effects of INT vs FR-1 schedules. However, interaction effects across conditions of the multielement design may be less likely to occur if the reinforcement schedules are associated with highly salient stimuli (e.g., different therapists, responses, settings, or times of day). In addition, sequence effects could be minimized in the reversal design by keeping conditions as brief as possible.

Unlike the PREE, the effects of intermittent punishment have been examined in a number of applied studies. Results of this research and implications for the use of punishment in applied settings are discussed in the next section.

Intermittent Schedules of Punishment

Basic studies with both humans and nonhumans have examined the effects of a variety of INT punishment schedules on behavior concurrently exposed to a schedule of reinforcement. Results generally indicate that amount of response suppression depends

on such factors as the type of punishment schedule, intensity of the punishing stimulus, and the particular schedule of reinforcement maintaining the target response (e.g., Azrin, 1956; Bradshaw, Szabadi, & Bevan, 1979; Scobie & Kaufman, 1969; Zimmerman & Ferster, 1963). In a review of this literature, however, Azrin and Holz (1966) concluded that punishment should be delivered on an FR-1 schedule to be most effective.

Nevertheless, results of applied studies have demonstrated that some INT punishment schedules are as effective as FR 1, particularly if the response has already been reduced to a low frequency. Clark, Rowbury, Baer, and Baer (1973) conducted one of the first systematic investigations of INT punishment schedules after successfully treating an 8-yr-old girl's disruptive behavior with an FR-1 schedule of isolation timeout. Using a reversal design, they examined three different VR schedules (VR 3, 4, and 8) and a schedule that specified delivery of timeout for any response that followed the previous one by less than 10 min (i.e., differential punishment of high rates [DPH]). Results indicated that when the punishment schedule was no leaner than about VR 4, treatment was nearly as effective as it was when timeout was delivered on an FR-1 schedule.

Results of subsequent studies examining INT schedules of isolation timeout (e.g., Calhoun & Lima, 1977; Calhoun & Matherne, 1975; Jackson & Calhoun, 1977) and studies examining other punishing stimuli, such as electric shock (Kircher, Pear, & Martin, 1971), lemon juice (Cipani, Brendlinger, McDowell, & Usher, 1991), verbal reprimands (Acker & O'Leary, 1988), and leg slaps (Romanczyk, 1977), generally have been consistent with the findings of Clark et al., suggesting that caregivers must use fairly short schedules of punishment -- but not necessarily an FR-1 schedule -- to effectively reduce problem behavior. For example, Romanczyk (1977) found that both FR-1 and VR-5 schedules had similar suppressive effects on two subjects' stereotypic behaviors.

Although most studies on INT punishment did not involve attempts to identify the sources of reinforcement maintaining the target responses, delivery of punishment is almost always confounded with the termination of reinforcement in applied research (Iwata, Pace, Cowdery et al., 1994). Thus, studies examining INT schedules may have combined punishment with extinction, a procedure that probably would increase the efficacy of INT punishment (cf. Azrin & Holz, 1961). In the Clark et al. study, for example, the subject's disruptive behavior may have been maintained by attention from peers or caregivers, and treatment with INT punishment may have included the cessation of contingent attention following all instances of disruption (both punished and unpunished responses). If so, certain INT schedules (e.g., VR 3) may have been effective because they were combined with extinction. On the other hand, leaner schedules (e.g., VR 8) combined with extinction may not have been powerful enough to produce significant decrements in responding (i.e., to hasten the extinction process).

Thus, the utility of punishment as treatment for severe behavior disorders maintained by unknown or uncontrolled sources of reinforcement may be limited unless every instance of the target response is followed by punishment. However, treatment programs that require such close, constant monitoring of behavior may be difficult to implement in settings with low staff-to-client ratios such as schools and residential facilities. It would be beneficial if caregivers could use INT schedules of punishment yet still obtain significant treatment effects. Although several authors have suggested that punishment schedules might be gradually "thinned" to increase the efficacy of INT punishment (e.g., Cipani et al., 1991; Kazdin, 1994), only one study has examined such a procedure.

Barton, Brulle, and Repp (1987) implemented a DPH schedule of timeout to decrease the aggression of three children in a classroom. The initial DPH schedule was determined for each subject by calculating the mean baseline interresponse time (IRT) of aggressive behavior. On the first day of treatment, the interval used for the DPH

schedule was equal to the mean baseline IRT, and this interval was adjusted daily throughout treatment to reflect the mean IRT from the previous day. The DPH schedule was implemented as follows: If the mean IRT was 2 min, the first target response that occurred during every 2-min interval did not produce timeout. All subsequent responses that occurred prior to the end of the interval were followed by the timeout procedure (contingent observation for two subjects and exclusion timeout for the third subject). The interval did not reset following each timeout; at the start of every consecutive 2-min interval, the first instance of aggression was not followed by timeout. Results demonstrated that treatment produced significant reductions in aggression for all subjects as the DPH interval was lengthened across several weeks.

This adjusting DPH schedule had several advantages. Because the schedule was based on the subject's current response rate, a high proportion of aggressive responses probably was followed by timeout. In addition, this time-based schedule may have been easier for the teachers to implement than other INT schedules, such as VR schedules (cf. Clark et al., 1974). However, results of this study are limited in several respects. First, *all* instances of aggression were followed by a verbal reprimand during treatment, a procedure that may have established the reprimand as a conditioned punisher and increased the efficacy of the DPH timeout schedule. In actuality, an FR-1 schedule may have been in effect throughout the study because all responses appeared to be followed by some type of punisher. Second, the study did not determine if gradual adjustment, or leaning, of the INT schedule was necessary to obtain significant reductions in aggression. That is, the terminal DPH schedule implemented for each subject may have been effective at the outset of treatment. Third, the punishment procedure may have been confounded with extinction. Finally, the utility of the DPH schedule was somewhat limited because, like FR 1, it required continual monitoring of behavior.

Additional research should determine if INT punishment schedules can be gradually "thinned" after behavior has been reduced by an FR-1 schedule so that initially ineffective

schedules can maintain low levels of problem behavior. The INT schedule should be relatively easy to implement and, if possible, allow discontinuous monitoring of behavior. For example, FI schedules, which have not yet been examined in applied research on INT punishment, seem particularly well-suited for this type of procedure. Monitoring the passage of time is probably less effortful than counting responses. In addition, interval schedules may be more effective than ratio schedules during the course of a fading procedure because nearly every response will be followed by punishment as long as response rates remain low (i.e., the behavior has a lengthy IRT).

Statement of Purpose

The current series of studies was designed to examine the effects of INT reinforcement and punishment on the efficacy of treatment (i.e., extinction or punishment) for severe behavior disorders. After identifying the variables maintaining problem behavior through functional analysis (Study 1), the effects of FR-1 versus INT schedules of reinforcement during subsequent extinction were examined for subjects whose target behaviors were maintained by social consequences (Study 2). To investigate the PREE, the study examined two different within-subject designs and several measures of resistance based on results of basic studies in this area. For subjects whose behaviors were not maintained by social reinforcement, the effects of INT punishment schedules on treatment with timeout or contingent restraint were examined (Study 3). After identifying an FI schedule that failed to produce significant reductions in behavior, an FR-1 schedule was gradually leaned in an attempt to maintain low levels of problem behavior under the initially ineffective FI schedule. The next section contains a description of general methods employed throughout the current series of studies.

GENERAL METHOD

Subjects and Setting

Five individuals diagnosed with profound mental retardation participated. All subjects lived in a public residential facility for individuals with developmental disabilities and were referred to a specialized program for the assessment and treatment of self-injurious behavior (SIB) based on histories of severe and/or chronic SIB.

Brandon, a 32-year-old man, was referred for treatment due to an extensive history of head hitting that had resulted in a cauliflower left ear. On occasion, Brandon would also exhibit aggressive and disruptive behaviors. He displayed no expressive language but was able to respond to a few simple requests. He could walk independently and had no visual or auditory impairment. Throughout the course of this study, Brandon received prescribed medication (chlorpromazine) for problem behavior, but no medication changes were implemented until the completion of the experiment. Brandon participated in Studies 1 and 2.

Sue was a 24-year-old woman whose SIB consisted of head hitting and hand biting. She did not display expressive verbal skills but was able to respond to some simple directions. She could walk independently and had no visual or auditory impairment. Sue received medication to control seizures during the course of this study. She participated in Studies 1 and 2.

Harold was a 39-year-old man who had a variety of severe behavior disorders, including SIB (head and body hitting, hand biting), aggression, and disruption. He had some expressive verbal skills, although his speech was difficult to understand, and he

could respond to simple requests. Harold could walk with assistance although he was confined to a wheelchair. He was blind due to cataracts but had no auditory impairment. Harold received medication to control seizures during the course of this experiment. He participated in Studies 1 and 2.

Paul was a 39-year-old man who had a long history of chronic hand mouthing, which had resulted in some tissue damage. Paul displayed no expressive language but was responsive to simple instructions. He could walk independently and had no visual or auditory impairment. Paul participated in Studies 1 and 3.

Merry was a 31-year-old woman who engaged in chronic hand mouthing that had produced extensive tissue damage. Merry displayed no expressive or receptive language and was confined to a wheelchair. She had no apparent visual or auditory impairment. She received medication to control seizures during the course of the experiment. Merry participated in Studies 1 and 3.

All sessions were conducted in therapy rooms of a day program located on the grounds of the residential facility. Rooms contained tables and chairs, as well as materials necessary for conducting certain conditions (see Procedures sections of the various studies). At least one observer was present during all sessions.

Human Subjects Considerations

Human subjects approval for these studies was obtained from the University Institutional Review Board and the facility where the day-treatment program was located. In order to assess and treat SIB (and related problem behaviors), subjects were permitted to freely engage in SIB for brief periods of time. Although SIB was likely to produce extensive physical damage within a session for only one subject (Brandon), several safeguards were established to reduce the risk of injury to all subjects. First, subjects was monitored daily by medical personnel at their homes, and a physician was available

(via telephone or beeper) during sessions at all times. Second, session termination criteria were established by medical personnel for Brandon (this was deemed unnecessary for the rest of the subjects). Third, a foam pad was readily available during all sessions to block potentially severe self-injurious responses, if necessary. With these safeguards, it was felt the degree of risk to which subjects were exposed was no greater than that found in their natural environment.

Response Measurement and Reliability

Response definitions were developed on the basis of staff interviews and informal observations of the subjects prior to the study. Self-injurious responses were defined as follows: face/head or body hitting (Brandon, Sue, Harold) -- forceful contact of an open or closed hand with any part of the face, head or other body part (e.g., leg, chest); hand biting (Sue, Harold) -- closure of the upper and lower teeth on the flesh anywhere on the hand or wrist; hand mouthing (Paul, Merry) -- contact of the tongue with any part of the hand or wrist, or insertion of any part of the hand or wrist between lips without biting. Aggression (Harold) was defined as hitting, kicking, or biting the therapist, and disruption (Harold) was defined as throwing objects or tearing clothing. Data also were collected on the following subject and experimenter responses: compliance with instructions; appropriate interaction with play materials; experimenter delivery of attention, instructions, or materials; and experimenter delivery of timeout or manual restraint.

Observers collected data using a hand-held computer (ASSISTANT, model A102) that audibly signaled 10-s intervals. Observers were graduate and undergraduate students who had previously demonstrated proficiency with this type of data collection by attaining a 90% agreement criterion for three consecutive sessions. Data were collected using frequency or partial-interval recording, and the data were calculated as responses

per minute (Brandon, Sue, and Harold) or percentage of 10-s intervals scored (Paul and Merry).

Interobserver agreement was assessed by having a second observer simultaneously but independently record data during 32% of all sessions (29% of sessions in Study 1, 35% of sessions in Study 2, and 29% of sessions in Study 3). In comparing observers' records, session time was divided into consecutive 10-s intervals, and agreement percentages were calculated on an interval-by-interval basis. The smaller number of responses in each interval was divided by the larger number of responses. These fractions were then summed across all intervals and divided by the total number of intervals in the session to get the percentage of agreement between the two observers. Mean agreement scores for SIB, aggression, or disruption were 98% overall (range, 94% to 99%). Mean agreement scores were 98% during Study 1 (range, 95% to 99%), 96% during Study 2 (range, 94% to 98%), and 98% during study 3 (range, 97% to 99%).

STUDY 1: FUNCTIONAL ANALYSIS OF PROBLEM BEHAVIOR

Procedures

All subjects participated in Study 1, which involved an experimental (functional) analysis to identify the variables maintaining SIB and other target behaviors (i.e., aggression and disruption for Harold). Subjects were repeatedly exposed to four conditions presented within a multielement design, based on procedures described by Iwata et al. (1982). In addition, two subjects (Brandon and Sue) were exposed to a fifth condition (see "Materials" below) based on information obtained from interviews with staff on their residence and through informal observations. All sessions lasted 15 min, and 2 to 3 sessions were conducted per day for each subject, usually 4 to 5 days per week.

Attention

In this condition, the subject was placed in a therapy room with a variety of leisure materials available (e.g., books, games, musical instruments). At the beginning of each session, the experimenter said, "I am here if you need me," and sat away from the subject. Throughout the session, the experimenter did not attend to the subject. Contingent on the target behavior(s), however, the experimenter provided attention in the form of statements of concern and disapproval (e.g., "Stop. You'll hurt yourself.") and physical contact (e.g., patting the subject's back). This condition was designed to test the effects of positive reinforcement (in the form of attention) on the rate of problem behavior.

Demand

The subject was placed in a therapy room with a variety of training tasks available. The experimenter presented learning trials to the subject every 30 s using a graduated prompting procedure (i.e., verbal instruction, modeling, physical guidance). The instructions included academic and self-care tasks to which the subjects were typically exposed on their residences (e.g., fold the towel, comb your hair, walk over here). Praise and pats on the back were delivered contingent on compliance without physical guidance. Contingent on the occurrence of the target response, the experimenter terminated the trial by removing the materials and turning away for 30 s. If the subject was exhibiting the target response at the time of the next scheduled trial, the experimenter delayed the trial until the subject had not exhibited problem behavior for 5 s. This condition was designed to test the effects of negative reinforcement (in the form of escape from instructions) on the rate of problem behavior.

Alone

In this condition, the subject was placed in a therapy room with no training or leisure materials available. No one was present in the room except an observer, and no interaction with the subject occurred. This condition, intended to simulate a "barren" environment, was designed to test the effects of automatic or self-stimulatory reinforcement on the rate of problem behavior.

Materials

This condition was designed to test the effects of positive reinforcement in the form of access to a specific item on the rate of SIB. Prior to the start of the session, the subject was permitted access to a preferred item (a game for Sue and shoes for Brandon). At the start of the session, the therapist removed the item. Contingent on each occurrence of SIB, the subject was provided access to the item for 30 s.

Play

This condition, intended to simulate an "enriched" environment, was designed to serve as a control for the other conditions. The subject was placed in a therapy room with a variety of leisure materials available. The experimenter delivered praise, physical contact, and materials every 30 s. No instructions were delivered, and all instances of problem behavior were ignored.

Results

Results of the subjects' functional analyses are shown in Figures 1, 2, and 3. Data for Brandon and Sue are shown in Figure 1. Both subjects exhibited the highest rates of SIB in the Materials condition. For Brandon (top panel), SIB ranged from 0 responses per minute (rpm) to about 6 rpm in the Materials condition. In the other conditions, SIB ranged from 0 rpm to about 1 rpm. Sue (bottom panel) exhibited SIB exclusively in the Materials condition. These results indicated that both subject's SIB was differentially sensitive to positive reinforcement in the form of access to a particular item.

Results of Harold's functional analysis are presented in Figure 2. All topographies of SIB (top panel), aggression (middle panel), and disruption (bottom panel) occurred exclusively in the Demand condition with the exception of one play session. These findings suggest that Harold's problem behaviors were members of the same response class, all differentially sensitive to negative reinforcement in the form of escape from instructions.

Results for Paul and Merry are shown in Figure 3. For Paul (top panel), the highest levels of hand mouthing occurred in the Alone condition ($M = 74.4\%$; range = 48% to 91%). In all other conditions, SIB generally ranged from 0% to 23%. For Merry (bottom panel), the highest amounts of hand mouthing occurred in the Demand ($M = 67.7\%$; range = 71% to 80%) and Alone ($M = 25.7\%$; range = 5% to 51%) conditions. In all other conditions, SIB ranged from 0% to 19%. Results for both subjects suggested

Figure 1. Results of the functional analysis for Brandon (top panel) and Sue (bottom panel).

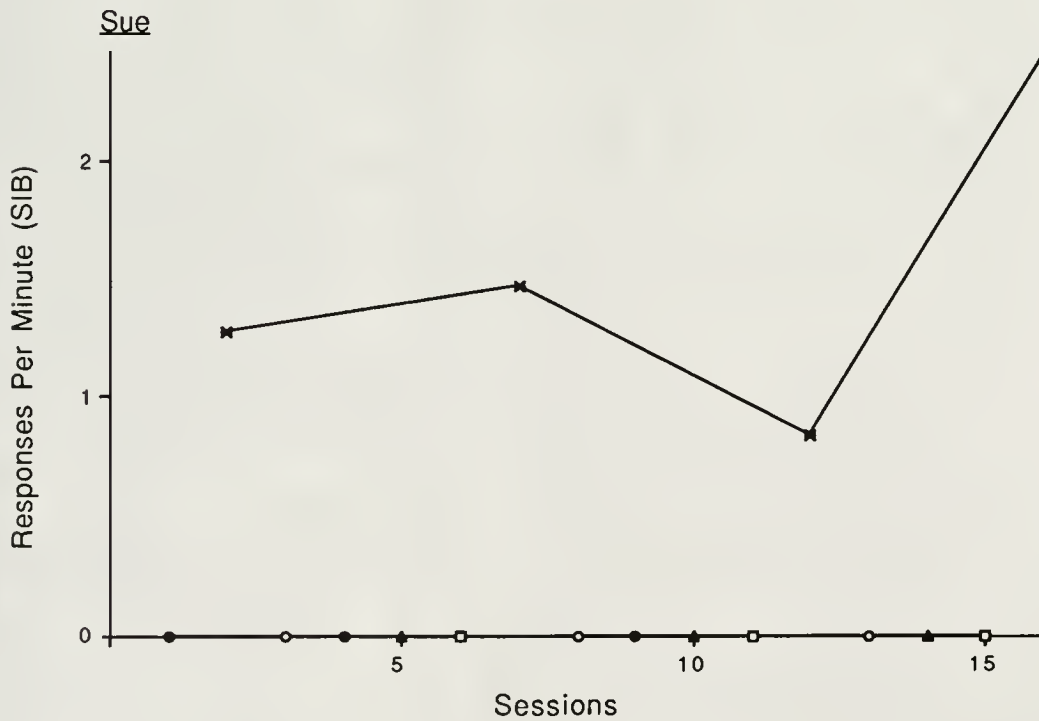
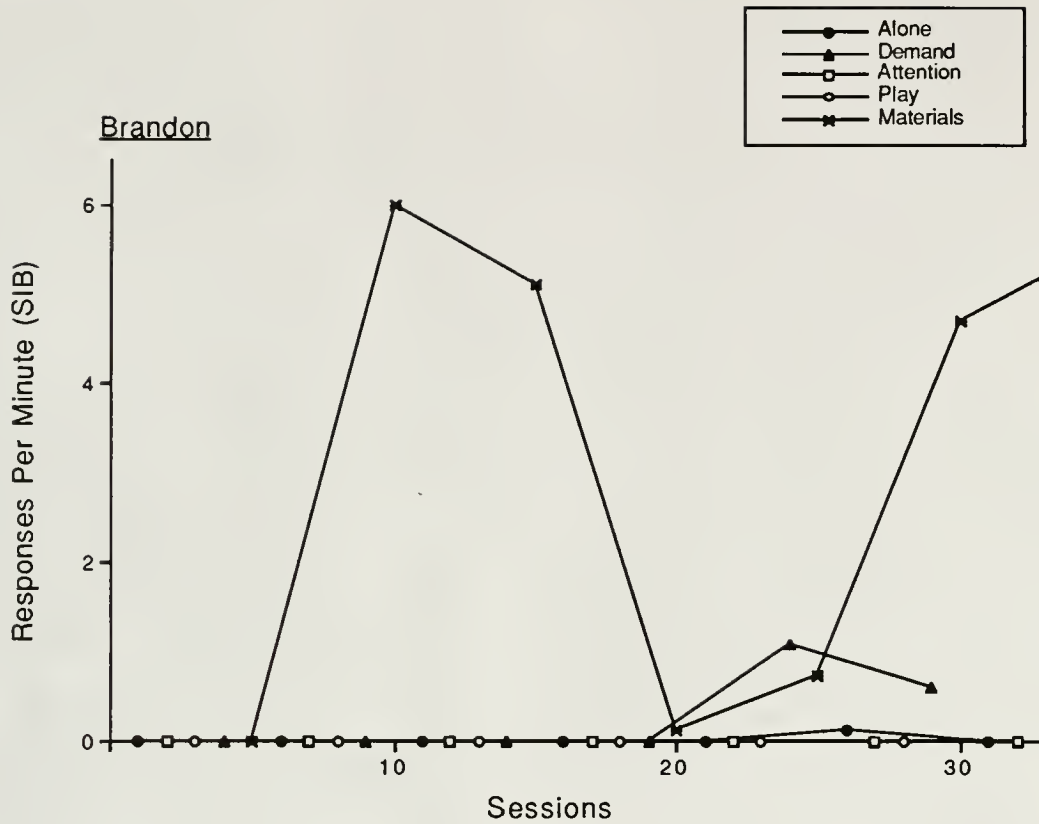


Figure 2. Results of the functional analysis for Harold. Rates of SIB are shown in the top panel, rates of aggression are shown in the middle panel, and rates of disruption are shown in the bottom panel.

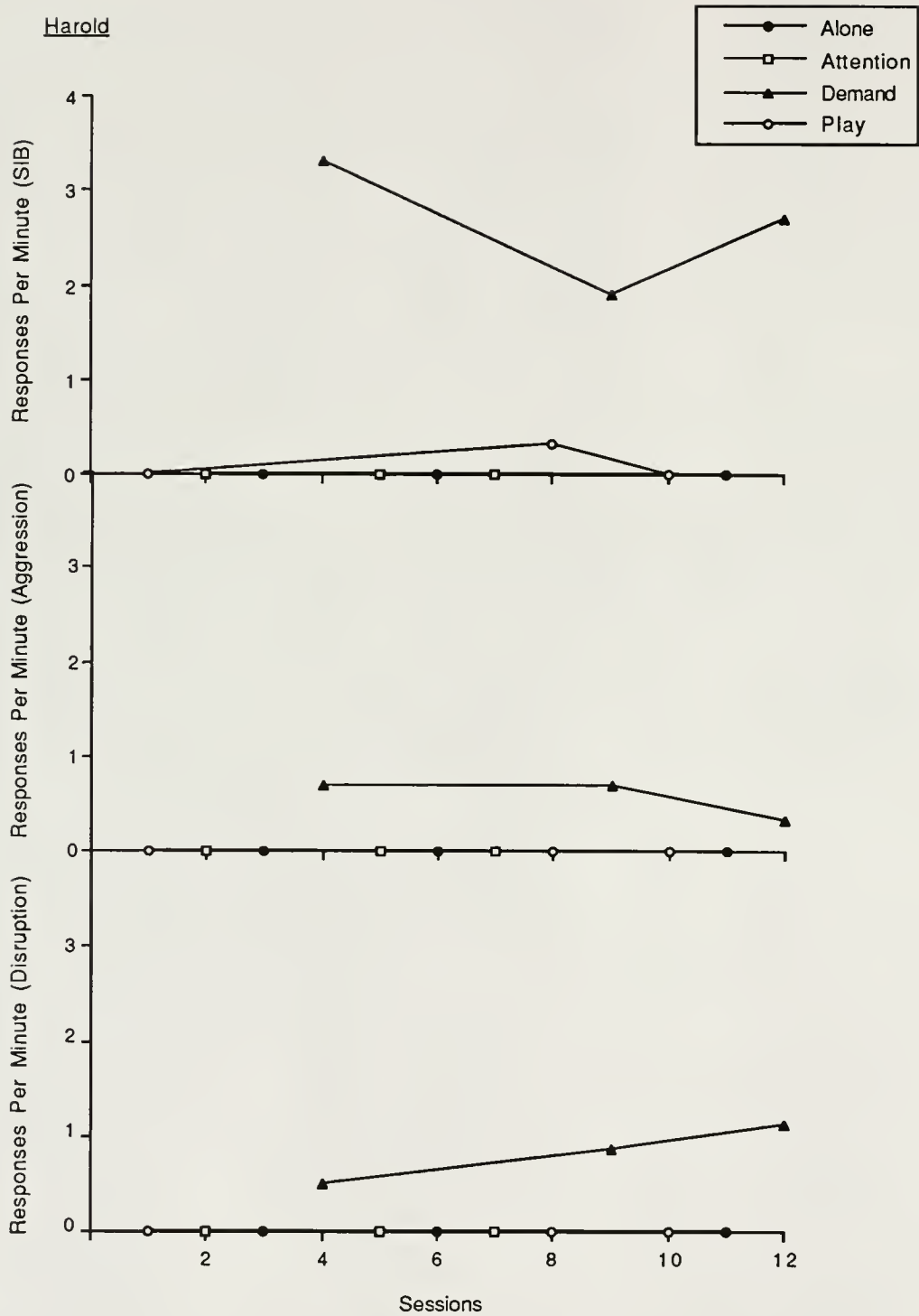
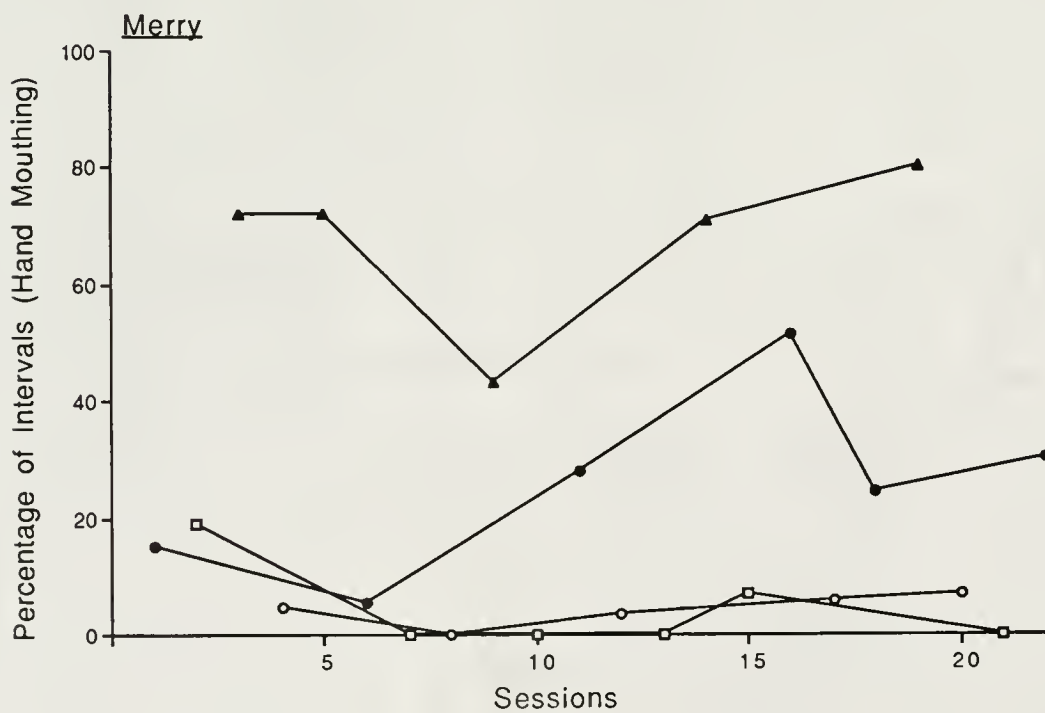
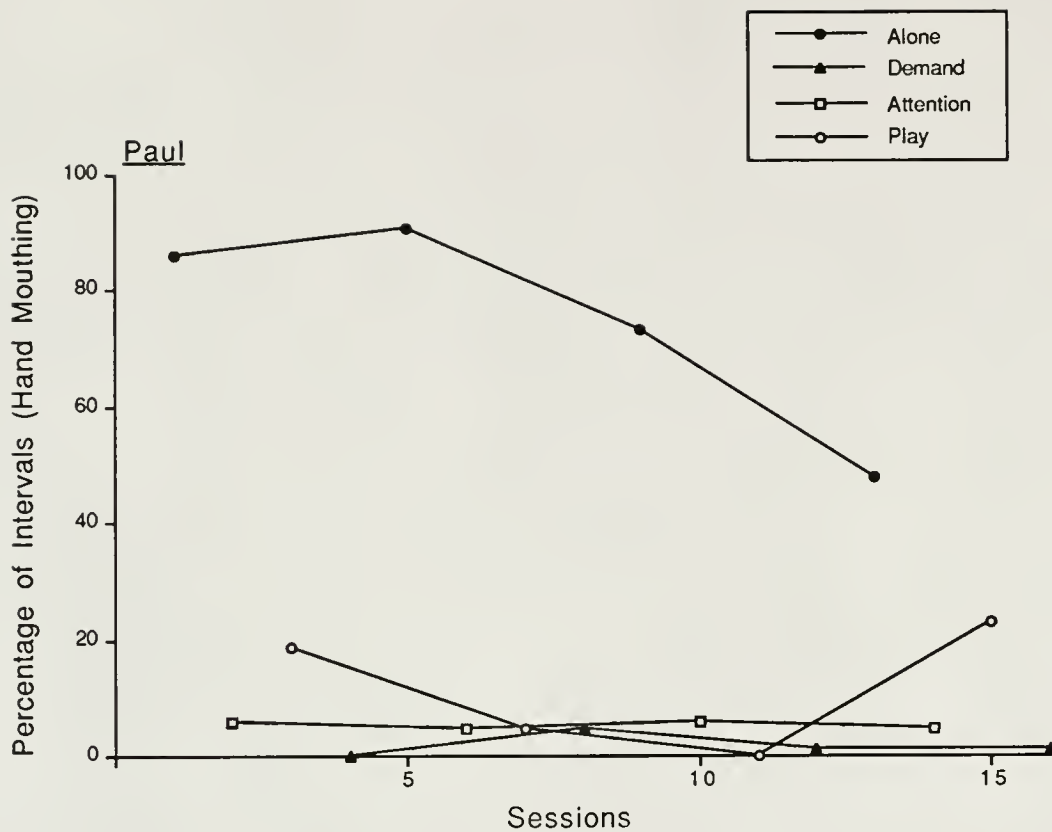


Figure 3. Results of the functional analysis for Paul (top panel) and Merry (bottom panel).



that SIB was maintained by automatic reinforcement. In addition, the findings for Merry suggested that her hand mouthing may have been sensitive to negative reinforcement in the form of escape from instructions.

Discussion

Results of these functional analyses replicate the findings of previous studies (e.g., Iwata et al., 1982, 1994; Derby et al., 1992), demonstrating the utility of the experimental analysis for revealing the variables maintaining problem behavior. The patterns of responding observed during the experimental conditions and the subsequent data interpretations were consistent with previous research in this area. Results of the functional analyses indicated that the subjects' SIB was multiply determined: two subject's SIB was maintained by positive reinforcement in the form of access to materials (Brandon and Sue), at least one subject's SIB was maintained by negative reinforcement in the form of escape from instructions (Harold), and two subject's SIB was maintained by automatic reinforcement (Paul and Merry).

Results also showed that the experimental analysis is useful for identifying the function of multiple response topographies exhibited by a single individual. Results for Harold indicated that all topographies of SIB, aggression, and disruption were members of the same functional response class. Data on these three categories of maladaptive behavior were analyzed separately because results of a recent study suggested that the function(s) of multiple topographies might be obscured when data for all behaviors are aggregated (Derby et al., 1994). However, the clear differentiation in Harold's data indicated that the negative reinforcement function would have been identified for all behaviors even if the results had been plotted in an aggregate fashion.

Results for two subjects (Brandon and Sue) demonstrated that the functional analysis is useful for identifying relatively idiosyncratic sources of reinforcement for SIB, such as access to specific items. An additional ("Materials") condition, designed to examine the

effects of a putative reinforcer identified via interviews with staff and informal observations of the subjects, was easily included in the general assessment protocol. Findings for both subjects clearly demonstrated the relevance of these specific items to maintenance of SIB and underscore the importance of using this type of background information to construct the conditions of the functional analysis.

Relative to the findings for the other subjects, results of Merry's assessment were somewhat equivocal. Merry exhibited moderate amounts of hand mouthing throughout the alone condition, suggesting that her behavior was at least partly maintained by automatic reinforcement. However, she engaged in even higher amounts of hand mouthing during the demand condition, indicating her behavior was differentially sensitive to negative reinforcement in addition to automatic reinforcement (i.e., that her hand mouthing was multiply controlled). However, further manipulations would have been necessary to investigate the source of these unclear results (see Smith, Iwata, Vollmer, & Zarcone, 1992). Although Merry's hand mouthing might have been multiply controlled, results of her assessment also could have been obscured by interaction effects across conditions. For example, some automatically-maintained SIB might have occurred during the Demand condition. On the other hand, escape-maintained SIB would not be expected to occur in the Alone condition because the relevant establishing operation for escape is absent from the alone sessions. Thus, additional manipulations to test the negative reinforcement hypothesis would have been necessary for Merry. Because Merry's chronic hand mouthing had produced extensive tissue damage and increased her risk for infection, it seemed important to treat her automatically-maintained SIB prior to conducting any further assessment manipulations.

Study 1 served as a screening device. Based on these results, individuals either participated in Study 2 to examine the PREE or in Study 3 to examine INT schedules of punishment.

STUDY 2: THE PARTIAL-REINFORCEMENT-EXTINCTION EFFECT AND IMPLICATIONS FOR THE TREATMENT OF PROBLEM BEHAVIOR

Procedures

Study 2 examined the PREE by exposing subjects to baseline conditions with FR-1 and INT reinforcement schedules, then comparing their performance during extinction. Brandon, Sue, and Harold participated in Study 2 because results of Study 1 indicated that their problem behaviors were maintained by social consequences (positive reinforcement for Brandon and Sue and negative reinforcement for Harold).

Two daily sessions were conducted for each subject, usually 4 days per week. Brandon and Sue were exposed to baseline (reinforcement) and extinction conditions alternated within a reversal design. For Harold, the PREE was examined using a multielement design, in which each reinforcement condition was associated with a specific therapist, setting, and time of day.

Baseline

During baseline conditions, the therapist used either FR-1 or INT schedules to deliver the maintaining reinforcer following occurrences of the target response(s). Subjects received five reinforcers during each session. The number of reinforcers (rather than session time) was held constant across baseline sessions because results of studies indicate that amount of reinforcement can influence resistance to extinction (e.g., Perin, 1942). For Brandon and Sue, procedures implemented during baseline sessions were identical to those implemented during the Materials condition of the functional analysis. For Harold, procedures implemented during the Demand condition of the functional

analysis were modified during baseline in two ways: (a) the contingent 30-s escape from instructions was increased to 1 min, and (b) instructions were delivered continuously throughout the session rather than on a FT-30 s schedule.

FR-1 baseline. The maintaining reinforcer was delivered following each occurrence of SIB (for all subjects), aggression (for Harold), or disruption (for Harold).

INT baseline. During this condition, the reinforcement schedule was gradually “thinned” across sessions until responding was maintained under a predetermined INT schedule. A number of considerations influenced the choice of the terminal INT schedule for each subject, including the types of schedules used in previous applied studies on the PREE and those that appeared to be operating in the natural environment based on informal observations of the subjects prior to the study. For Brandon, Sue, and Harold, the terminal INT schedules were VR 6 (range, 4 to 8 responses), FR 3, and VR 10 (range, 5 to 15 responses), respectively. The VR schedules were constructed by writing numbers (i.e., the predetermined response requirement range) on individual slips of paper. Prior to each session, the response requirement for each reinforcement delivery was determined by randomly choosing five slips of paper from the box and adjusting the fifth number as necessary to ensure that the correct average was obtained. Harold was exposed to the FR-1 and INT conditions concurrently. His FR-1 baseline sessions were conducted during the morning by one therapist in a room at the day program. His INT sessions were conducted during the afternoon by a different therapist in his residence dining room.

Extinction

During these sessions, reinforcement was no longer delivered following occurrences of the target behaviors. For Brandon and Sue, the preferred item was removed at the start of the session, and all SIB was ignored. For Harold, the graduated prompting sequence simply continued while all instances of inappropriate behavior were ignored. Unlike baseline sessions, however, instructions were delivered on a FT-30 s schedule to

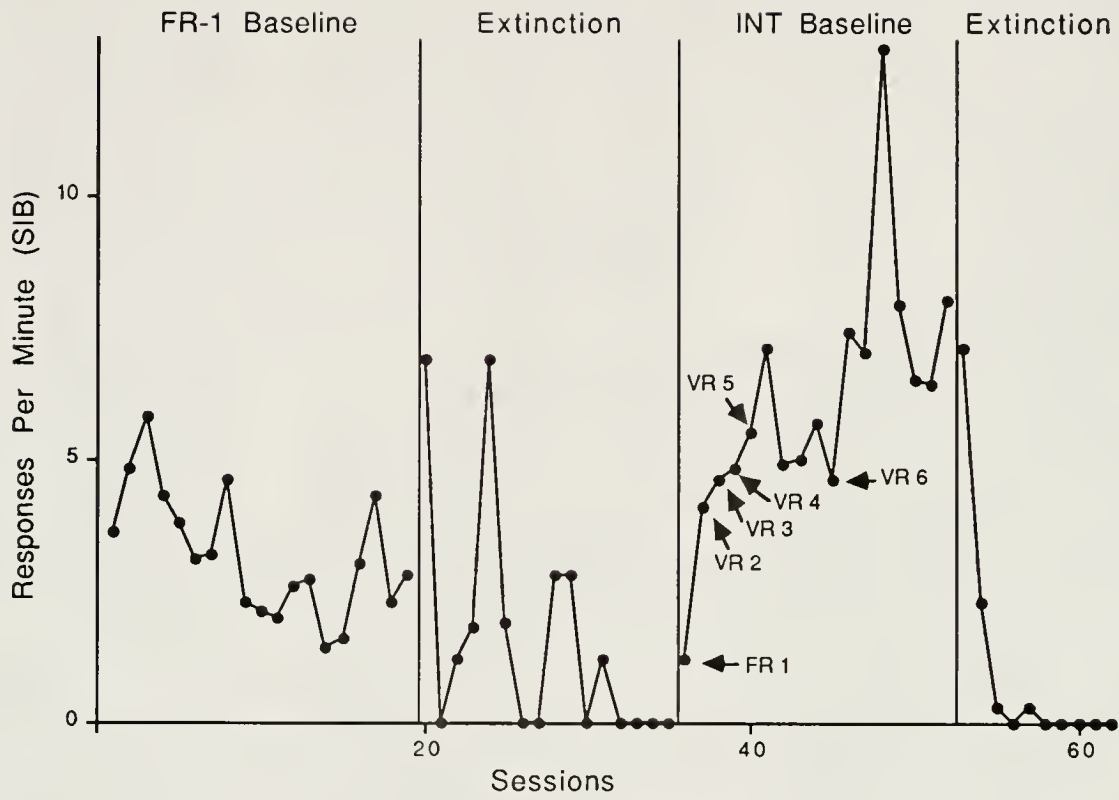
ensure that equal numbers of instructions were delivered across all extinction sessions. Session length was determined for each subject by calculating the average baseline session length. Sessions lasted 10 min for Brandon and Harold and 5 min for Sue.

Results

The results of Study 2 are shown in Figures 4, 5, 6, and 7, and are summarized in Table 1. Several different measures of resistance were examined for each subject. Data from all sessions were calculated as responses per minute by dividing the total number of responses by the number of minutes of session time. The total number of responses and sessions that occurred during each extinction phase also were calculated, and the slopes of linear regression lines fitted to the data from each extinction phase (using the method of least squares) were compared. Finally, response rates during extinction sessions were expressed as proportions of the baseline rate (from the immediately preceding baseline condition) by dividing the response rate for each extinction session by the average baseline response rate, which was calculated from the last 5 sessions.

Figure 4 shows Brandon's response rates during all baseline and extinction sessions. Brandon was first exposed to the FR-1 baseline. Although a slight descending trend is seen during this phase, responding remained fairly stable across the last 8 sessions ($M = 2.8$ rpm during the last 5 sessions). With the introduction of extinction, responding increased and became more variable, then decreased to zero levels. The extinction phase was terminated when Brandon had not exhibited SIB for four consecutive sessions, and this performance level (no SIB for four consecutive sessions) was established as the termination criterion for the subsequent extinction phase. Brandon exhibited 255 self-injurious responses across 16 sessions ($M = 1.6$ rpm) before the first extinction phase was terminated.

Figure 4. Rates of SIB for Brandon across sessions in Study 2.

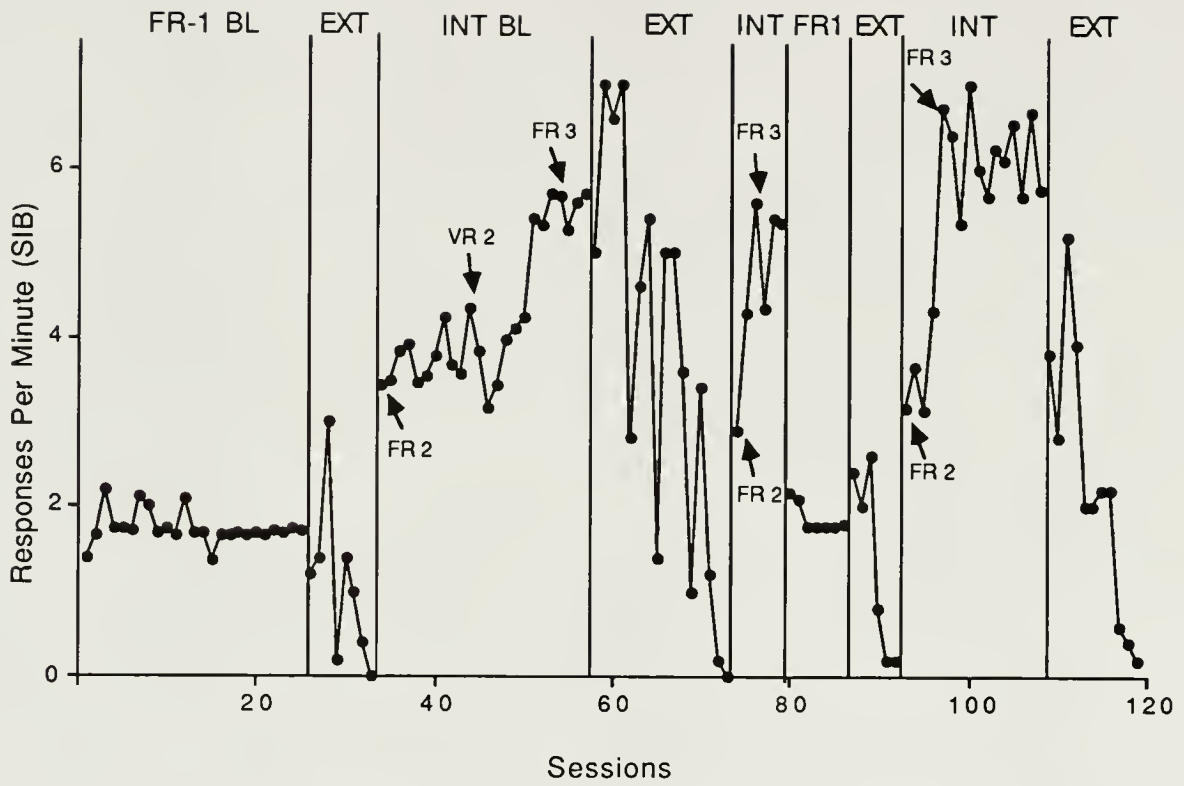
Brandon

The therapist then attempted to reimplement the FR-1 baseline to recapture responding before leaning the schedule during the INT baseline phase. However, Brandon continued to exhibit no SIB for the next several days (data not shown), and as a result, his behavior did not come into contact with the altered contingency. Brandon was then placed in a different therapy room at the treatment center. SIB abruptly reappeared in the new therapy room, and responding gradually increased as the reinforcement schedule was leaned to VR 6 ($M = 8.3$ rpm during the last 5 sessions). During extinction, SIB rapidly decreased to zero levels, and Brandon exhibited only 100 self-injurious responses across 9 sessions ($M = 1.1$ rpm) before satisfying the termination criterion.

Rate of change in responding during extinction was examined by calculating the slopes of linear regression lines fitted to the data from each extinction phase. Results showed that rate of decrease in responding during Brandon's second exposure to extinction (slope = - 0.6) was greater than that during Brandon's first exposure to extinction (slope = - 0.2). Thus, Brandon's data showed a "reversed PREE" based on several different measures of resistance, including response rate, total number of responses, number of sessions to meet an extinction criterion, and rate of change in responding (slopes). That is, resistance to extinction was greater following exposure to an FR-1 reinforcement schedule than following exposure to an INT schedule.

Results for Sue are displayed in Figure 5. The figure shows responses per minute of SIB across all baseline and extinction sessions. Sue was first exposed to the FR-1 baseline condition, during which rates of SIB were extremely stable ($M = 1.7$ rpm during the last 5 sessions). With the introduction of extinction, responding initially increased and then rapidly decreased to zero. To minimize potential sequence effects, the extinction criterion selected for Sue (i.e., 2 sessions in a row with SIB at or below 0.5 rpm) was

Figure 5. Rates of SIB for Sue across sessions in Study 2.

Sue

more lenient than that selected for Brandon. Sue exhibited just 43 self-injurious responses across 8 sessions ($M = 1.1$ rpm) before satisfying this criterion. During the INT baseline phase, rate of SIB increased as the schedule was leaned from FR 2 to FR 3 ($M = 5.6$ rpm during the last 5 sessions). The reintroduction of extinction produced a pattern of responding similar to that observed in the first extinction phase (i.e., SIB initially increased and then decreased to zero). However, Sue exhibited 301 self-injurious responses across 16 sessions ($M = 3.8$ rpm) before satisfying the extinction criterion. Thus, Sue exhibited seven times more self-injurious responses and required twice as many sessions to meet the termination criterion during the second extinction phase (following the INT baseline) than during the first extinction phase (following the FR-1 baseline). Based on these measures of resistance (response rate, number of responses, and number of sessions to meet an extinction criterion), Sue's data appeared to demonstrate a PREE.

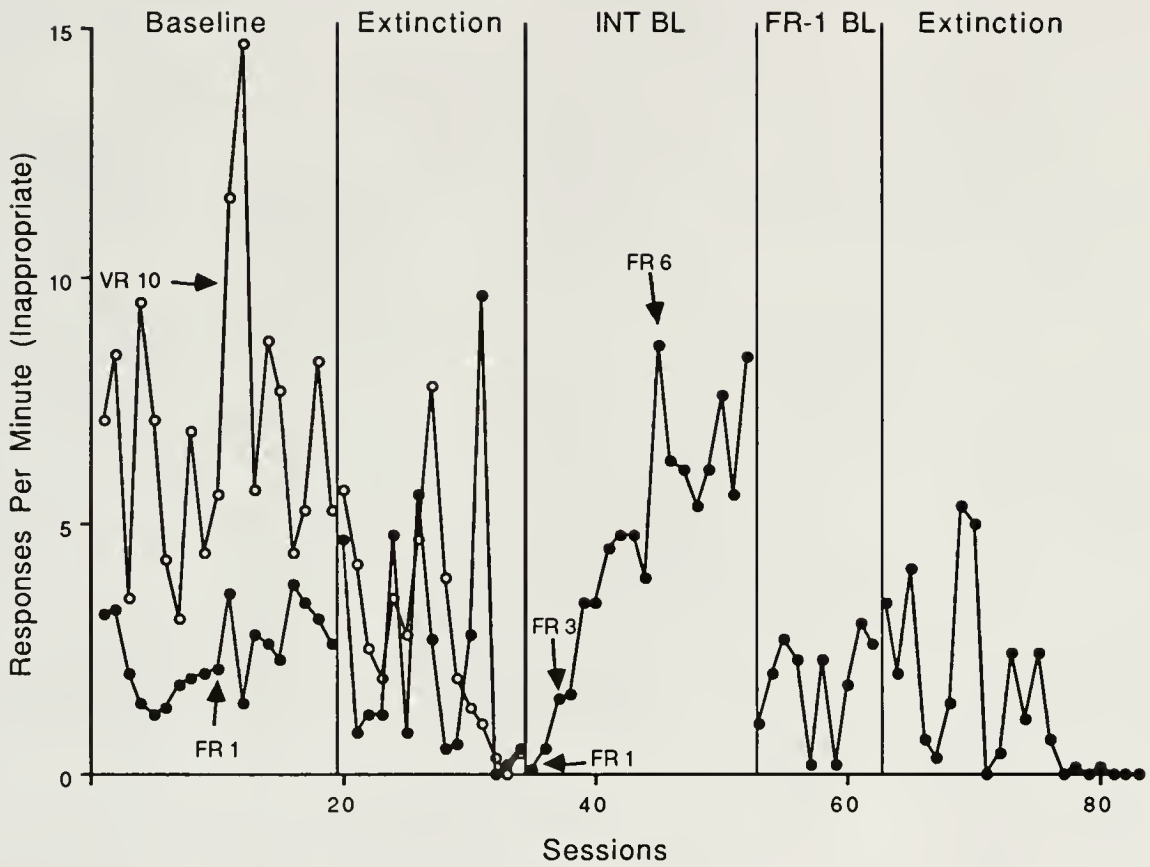
Rate of change in responding also was examined for Sue by calculating the slopes of linear regression lines fitted to the data from each extinction phase. Results showed that rate of decrease in responding during the second exposure to extinction (slope = - 0.4) was somewhat greater than that during the first exposure to extinction (slope = - 0.2). These data were indicative of a small "reversed PREE."

The next phases were designed to replicate the previous conditions and to investigate the advantages of switching from an INT to an FR-1 schedule prior to treatment with extinction. During the first phase, the therapist reimplemented the INT schedule, which was leaned to FR 3, and then changed the schedule to FR 1. Rates of SIB during the INT baseline sessions were similar to those observed during the initial INT phase, and responding abruptly decreased with the transition from the INT to the FR-1 schedule. Results of these phases, which replicated those obtained in the first part of the study, showed that SIB maintained at a much higher level under the INT schedule ($M = 4.6$

rpm) than under the FR-1 schedule ($M = 1.8$ rpm). The introduction of extinction again resulted in an initial increase in SIB followed by a rapid decrease to low levels. Sue exhibited 41 self-injurious responses across 6 sessions ($M = 1.4$ rpm) before meeting the extinction criterion. During the final phases for Sue, the INT baseline and extinction conditions were reimplemented to compare responding during extinction after INT reinforcement to responding during extinction after a switch from an INT to an FR-1 schedule. As the figure shows, rates of SIB during the final exposure to the INT baseline and extinction conditions were similar to those observed during Sue's previous exposures to these conditions. Sue exhibited 127 self-injurious responses across 11 sessions ($M = 2.3$ rpm) before meeting the extinction criterion. Thus, Sue exhibited about three times as many self-injurious responses and required nearly twice as many sessions to meet the termination criterion during the last extinction phase (following the INT baseline) than during the third extinction phase (following a switch from INT to FR-1 baseline conditions). Rate of change in responding during these two extinction phases was again examined for Sue. Results showed that rate of change during the final exposure to extinction (slope = -0.4) was slightly lower than that during the first exposure to extinction (slope = -0.5). Thus, results of these replication phases appeared to indicate that resistance to extinction was greater following INT reinforcement than following a switch from an INT to an FR-1 schedule. These findings suggested that treatment with extinction might be improved by switching from an INT to an FR-1 schedule prior to extinction.

Data for Harold are shown in Figure 6. The figure displays rates of inappropriate behavior (SIB, aggression, and disruption) during the reinforcement and extinction sessions with each therapist. Results showed that responding was much higher during the INT reinforcement sessions ($M = 7.1$ rpm for the last 5 sessions) than during the FR-1 sessions ($M = 1.5$ rpm for the last 5 sessions). The therapists simultaneously switched

Figure 6. Rates of SIB for Harold across sessions in Study 2.

Harold

to extinction in their respective settings. The extinction criterion selected for Harold was SIB at or below 0.5 rpm for 3 consecutive sessions with both therapists. That is, extinction would continue with each therapist until this criterion was met during both morning and afternoon sessions. Results for the extinction condition showed that responding following the FR-1 baseline initially increased and became more variable before gradually decreasing to low levels. Following the VR 10 baseline, responding gradually decreased to low levels. The termination criterion was satisfied after each therapist had implemented 15 sessions. Harold exhibited 360 responses ($M = 2.4$ rpm) during extinction sessions with the FR-1 therapist and 419 responses ($M = 2.8$ rpm) during extinction with the INT therapist. Rate of change in responding during extinction also was examined for Harold by calculating the slopes of linear regression lines fitted to the data from sessions with each therapist. Results showed that rate of change in responding following INT reinforcement (slope = -0.3) was greater than following FR 1 (slope = $-.06$). Thus, as measured by response rates, total number of responses, and number of sessions to meet the extinction criterion, resistance to extinction following the INT baseline was not significantly greater than that following the FR-1 baseline. Further, the rate of change measure (slopes) was indicative of a “reversed PREE” for Harold.

The next phases were designed to replicate the previous baseline and extinction conditions. It could be argued, for example, that rate of behavior was higher under the VR-10 baseline than under the FR-1 baseline because INT reinforcement was associated with a specific therapist, setting, or time of day. Thus, the therapist initially associated with the FR-1 baseline implemented an INT baseline (in the morning at the day program). Results showed that rates of problem behavior increased when the reinforcement schedule was gradually leaned to FR 6 ($M = 6.2$ rpm during the last 5 sessions), and responding abruptly decreased and maintained at a low level ($M = 1.8$ rpm) when the

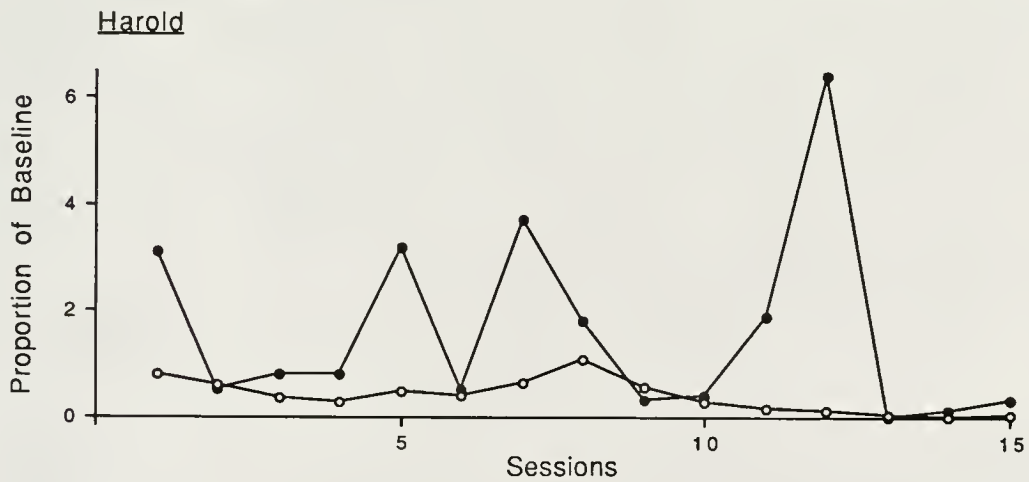
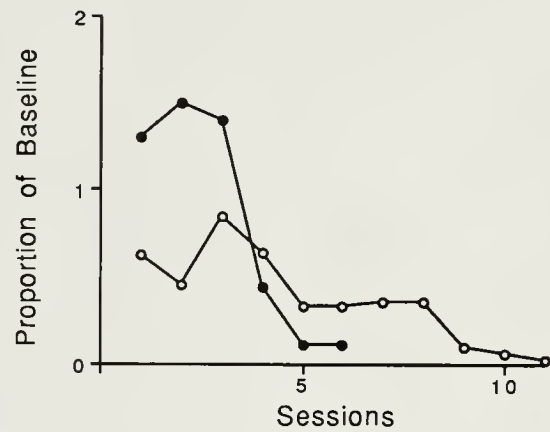
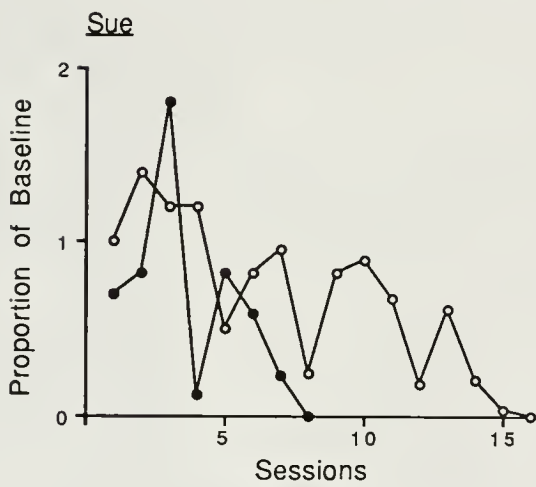
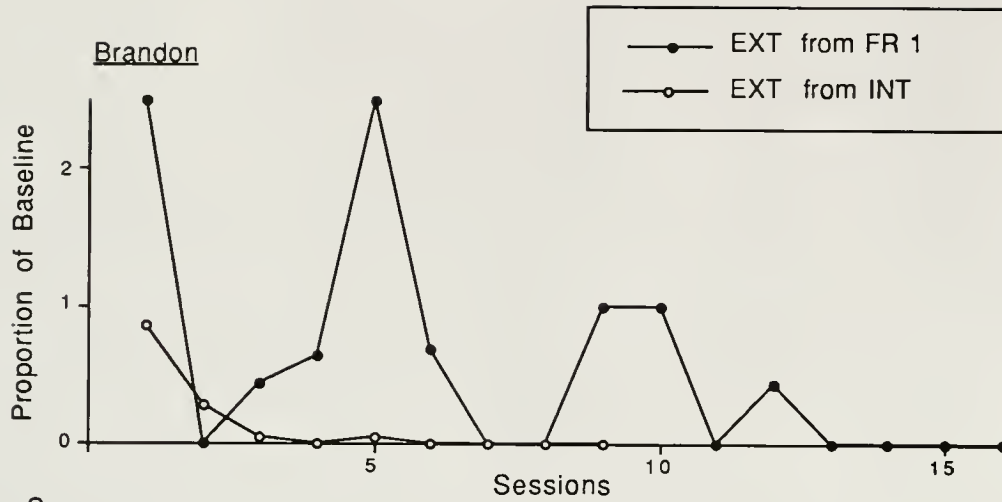
therapist switched to an FR-1 schedule. These findings replicated those of previous phases showing that response rates were much higher under INT reinforcement than under FR 1. With the introduction of extinction, responding gradually decreased to near zero levels and remained low across seven sessions.

Overall, these findings suggested that a clear “reversed PREE” occurred for one subject (Brandon), a potential PREE occurred for another subject (Sue), and no PREE occurred for a third subject (Harold). As noted above, however, some authors have argued that data on the PREE should be transformed to adjust for baseline differences in responding associated with different reinforcement schedules (e.g., Anderson, 1963; Nevin, 1988). The terminal rate of problem behavior for all subjects was consistently much higher under the INT schedule than under the FR-1 schedule. For Sue, this difference might partially account for the higher response rates, number of responses, and total number of sessions observed during extinction following the INT schedule (cf. Nevin, 1988). For Harold, these differences might obscure a clear “reversed PREE.”

Figure 7 shows the data for each extinction session expressed as a proportion of the baseline response rate. Higher proportions indicate greater resistance to extinction. Results for Brandon are displayed in the top panel. As the figure shows, the proportion of baseline measure for the FR-1/extinction sessions ($M = 0.6$) was consistently higher than that for the INT/extinction sessions ($M = 0.1$).

The middle panel shows the results for Sue. The left figure displays the data from Sue’s first exposure to the two reinforcement schedules and extinction. The proportion of baseline measure for the INT/extinction sessions ($M = 0.6$) was not consistently higher than that for the FR-1/extinction sessions ($M = 0.6$). The right figure, which shows the data from Sue’s second exposure to the two reinforcement schedules and extinction, indicates that the proportion of baseline measure for the INT/extinction sessions ($M = 0.4$) was significantly lower than that for the INT-FR-1/extinction

Figure 7. Proportion of baseline measure for each extinction session in Study 2 for Brandon (top panel), Sue (middle panel), and Harold (bottom panel).



sessions ($M = 0.7$). Thus Sue's data demonstrated no PREE during her first exposure to extinction and a "reversed" PREE during her second, using the measure of resistance recommended by Nevin (1988).

The bottom panel displays the proportion of baseline measure for each extinction session during Harold's first exposure to the two reinforcement conditions and extinction. Results showed that the proportion of baseline measure for the FR-1/extinction sessions ($M = 1.6$) was consistently higher than that for the INT/extinction sessions ($M = 0.4$), indicating a "reversed PREE" for Harold.

Results for all subjects are summarized in Table 1. In addition, rates of reinforcement delivered under the FR-1 and INT schedules are shown in the table. As discussed above, Nevin (1974, 1979, 1988) has suggested that reinforcement rate (rather than intermittency *per se*) can determine resistance to extinction. For all subjects, the average reinforcement rate under each reinforcement schedule was calculated by dividing the total number of reinforcers delivered by the total minutes of session time. Reinforcement rates were then compared to the various data interpretations.

Results for Brandon are shown in the top panel. All measures of resistance appear to demonstrate a "reversed PREE" for Brandon, and rates of reinforcement delivered under the two baseline conditions are somewhat consistent with this interpretation. That is, reinforcement rate under FR 1 ($M = 1.2$) was slightly higher than that under INT reinforcement ($M = 1.0$)

Results for Sue are shown in the middle panel. For the initial demonstration (left side), several measures of resistance suggest the occurrence of a PREE (i.e., response rate, number of responses, number of sessions to meet the extinction criterion), whereas other measures of resistance indicate either no PREE (proportion of baseline measure) or a "reversed PREE" (rate of change in responding). These equivocal results are consistent with the finding that reinforcement rates were equivalent under the FR-1 and INT

Table 1
Summary of Data During Extinction and Interpretation of Findings
Following FR 1 and INT Reinforcement

(PREE = partial-reinforcement-extinction effect; RPREE = “reversed” partial-reinforcement-extinction effect; NPREE = no partial-reinforcement-extinction effect)

<u>Brandon</u>			
<u>Measures</u>	<u>FR 1</u>	<u>INT</u>	<u>Interpretation</u>
Mean Resp Rate	1.6	1.1	RPREE
# of Responses	255	100	RPREE
# of Sessions	16	9	RPREE
Slope	-.25	-.60	RPREE
Mean Prop of BL	0.6	0.1	RPREE
Rate of Rfmnt	1.2	1.0	

<u>Sue</u>						
<u>Measures</u>	<u>FR 1</u>	<u>INT</u>	<u>Interp</u>	<u>INT-FR 1</u>	<u>INT</u>	<u>Interp</u>
Mean Resp Rate	1.1	3.8	PREE	1.4	2.3	PREE
# of Responses	43	301	PREE	41	127	PREE
# of Sessions	8	16	PREE	6	11	PREE
Slope	-.22	-.40	RPREE	-.52	-.40	PREE
Mean Prop of BL	0.6	0.6	NPREE	0.7	0.4	RPREE
Rate of Rfmnt	1.7	1.7		1.8	1.8	

<u>Harold</u>			
<u>Measures</u>	<u>FR 1</u>	<u>INT</u>	<u>Interpretation</u>
Mean Resp Rate	2.4	2.8	NPREE
# of Responses	360	419	NPREE
# of Sessions	15	15	NPREE
Slope	-0.06	-.32	RPREE
Mean Prop of BL	1.6	0.4	RPREE
Rate of Rfmnt	.75	.41	

schedules ($M = 1.7$). For the second demonstration (right side), data on response rate, number of responses, number of sessions, and rate of change in responding support a PREE interpretation of the findings, whereas the proportion of baseline measure indicates a “reversed PREE.” Again, these equivocal results are consistent with finding that reinforcers were delivered at equal rates under the two reinforcement conditions ($M = 1.8$).

Results for Harold are displayed in the bottom panel. Although several measures of resistance (i.e., response rate, number of responses or sessions) indicate no significant differences in responding following FR-1 and INT baselines, rate of response decrease (slopes) and the proportion of baseline measure suggest the occurrence of a “reversed PREE.” Further, reinforcement rates (0.7 under FR 1 and 0.4 under INT) are consistent with the “reversed PREE” interpretation of Harold’s data.

Discussion

This study investigated the clinical significance of the PREE with individuals who engaged in severe behavior disorders. The study examined two different within-subject experimental designs and several measures of resistance. Results suggested that problem behaviors, such as SIB and aggression, may not be more difficult to treat with extinction if they have been maintained on INT rather than FR-1 schedules and that texts on application may have overemphasized the potential for treatment difficulties generated by the PREE. When traditional measures of resistance (e.g., response rate, number of responses or sessions) were examined, a PREE was obtained with one subject (Sue), a “reversed PREE” was obtained with another subject (Brandon), and no PREE was obtained with a third subject (Harold). Results further demonstrated a “reversed PREE” for two subjects (Brandon and Harold) and no PREE for a third subject (Sue) when rate

of decrease in responding (slopes of extinction curves) and the proportion of baseline measure were examined.

Results of this study also demonstrated that rate of inappropriate behavior can be extremely sensitive to changes in reinforcement schedule. For all subjects, responding under INT reinforcement was consistently higher than responding under FR 1. Most likely, this resulted in the higher initial response rates during extinction following the INT baseline (see results for Sue and Harold). These findings suggest that switching from an INT to an FR-1 schedule prior to treatment with extinction might lower the baseline response rate, as well as the total number of responses exhibited during extinction. Such an effect would be particularly desirable when treating severe behavior disorders, such as SIB. For example, Sue exhibited only 41 self-injurious responses during extinction when the INT schedule was switched to FR 1, but she exhibited 127 responses when the subsequent extinction phase followed an INT baseline. Although recommended by various authors as a means to attenuate or eliminate the PREE (see Ducharme & Van Houten, 1994), this treatment strategy is based solely on response rate as a function of the baseline reinforcement schedule.

Nevin (1979, 1988, 1992) has suggested that reinforcement rate rather than the particular reinforcement schedule can determine resistance to extinction, and results of this study appear to support this hypothesis. For two subjects (Brandon and Harold), a comparison of the reinforcement rates delivered under the INT and FR-1 schedules demonstrated that the schedule associated with the highest rate of reinforcement was associated with the greatest resistance to extinction (using the measures of resistance recommended by Nevin [1988]). Such a finding indicates that reinforcement rate also should be examined (and perhaps altered) in the natural environment before treating problem behaviors with extinction.

Although results of this study appear to have important implications for the use of extinction in applied settings, the findings should be considered preliminary due to a number of potential limitations. For example, use of within-subject designs may have significantly influenced the results. First, sequence effects associated with the reversal design may have been responsible for the “reversed PREE” and no PREE demonstrated for Brandon and Sue, respectively. That is, their first exposure to extinction (following FR 1) may have led to a reduction in resistance during their second exposure to extinction (following INT). Results of some basic studies indicate that resistance can decrease across repeated exposures to extinction (e.g., Bullock & Smith, 1953; Clark & Taylor, 1960). In this study, extinction phases were kept as brief as possible to minimize the potential influence of sequence effects. However, data for Brandon, who had the most stringent extinction criterion, appear to suggest the occurrence of such effects.

Second, interaction effects across conditions of the multielement design may have been responsible for the absence of a PREE for Harold. Because several basic studies have obtained the PREE when salient stimuli were associated with the different components of a multiple schedule (e.g., Feider, 1973; Waters & Knott, 1970), conditions for Harold were paired with specific therapists, settings, and times of day. Nevertheless, Harold met the extinction criterion simultaneously with both therapists, suggesting that interaction effects may have occurred during extinction. That is, exposure to extinction in the morning at the day program (following FR 1) may have led to less resistance to extinction during the afternoon sessions at Harold’s residence (following INT). Such an effect is not merely speculative; results of basic studies using the multiple-schedule design indicate that interaction effects can occur during extinction, obscuring the PREE (e.g., Amsel et al., 1966).

Other factors, such as the reinforcement schedules used during the INT baselines, also may have decreased the possibility of obtaining a significant PREE in this study.

For example, leaner reinforcement schedules, lengthier baseline phases, or different extinction (termination) criteria may have altered the findings. Nevertheless, the parameters implemented in this study were similar to those used in studies that have obtained the PREE.

Additional research on the clinical significance of the PREE with severe behavior disorders seems warranted. Studies should examine the effects of reinforcement schedule and rate of reinforcement on responding during extinction, as well as the benefits of switching from an INT to an FR-1 schedule prior to treatment. Although several studies have attempted to examine the benefits of altering reinforcement schedules while treating problem behavior (e.g., Foxx & McMorro, 1983; Neisworth, Hunt, Gallop, & Madle, 1985; Schmid, 1986), conclusions about the effects of switching from INT to FR-1 schedules prior to extinction cannot be formed on the basis of their findings. In these studies, the contingencies maintaining subjects' inappropriate behavior (stereotypy) were not identified, and it was assumed that the behaviors were maintained by INT schedules of automatic reinforcement. Because sources of automatic reinforcement are difficult to manipulate, arbitrary reinforcers (e.g., food items) were delivered following each occurrence of stereotypy (i.e., on an FR-1 schedule) and then removed in an attempt to decrease the behavior. Results suggested that the procedure produced short-term reductions in stereotypy for some of the subjects. However, these studies demonstrated the effects of introducing and removing an arbitrary reinforcer on behavior maintained by an unidentified reinforcer, not the effects of switching reinforcement schedules prior to extinction.

Further studies on the PREE also should attempt to determine which measures of resistance have the greatest relevance to applied problems. Possibly, all measures (e.g., response rate, slope of extinction curves) can be important, depending on the situation. For example, results of additional research might indicate that INT reinforcement is associated with more responses during extinction but faster decrements in responding

(i.e., steeper extinction curve slopes) than FR 1. In this case, the FR-1 baseline may be more desirable than the INT baseline when treating severe behaviors disorders, such as SIB, but less desirable than the INT baseline when treating other types of problem behaviors, such as mild forms of stereotypy and disruption.

Texts and articles on application (e.g., LaVigna & Donnellan, 1986; Romanczyk, Kistner, & Plenis, 1982) generally describe extinction as a relatively inefficient treatment procedure that may be associated with a number of undesirable side effects, such as initial increases in response frequency (i.e., “extinction bursts”) and aggression (i.e., “extinction-induced aggression”). As a result, extinction is rarely recommended as a singular intervention for severe behavior disorders. Nevertheless, robust treatment effects were obtained in this study by simply terminating the contingency between responding and reinforcement during brief (5- or 10-min) sessions. For all subjects, target behaviors were reduced to low levels within 16 sessions (range = 6 to 16 sessions), and few problems were noted with the exception of response bursting during the initial stages of treatment. However, all extinction bursts were relatively brief and tended to follow FR-1 rather than INT reinforcement baselines. These results are consistent with those of previous studies demonstrating the utility of extinction as treatment for problem behavior (e.g., Carr, Newsom, & Binkoff, 1980; Forehand, 1973; France & Hudson, 1990; Iwata et al., 1990; Iwata et al., 1994; Mazaleski et al., 1993; Salend & Meddaugh, 1985).

The current investigation may serve as an impetus for additional studies in this area. Basic research findings suggest that a variety of factors other than reinforcement schedules can influence performance during extinction (see Mackintosh, 1974, for a review). Further examination of these factors, including reinforcer magnitude, reinforcement delay, and response effort, could lead to the development of a comprehensive technology for the use of extinction in applied settings.

STUDY 3: INCREASING THE EFFECTIVENESS OF INTERMITTENT PUNISHMENT VIA SCHEDULE FADING

Procedures

Study 3 examined a procedure to increase the efficacy of intermittent punishment for behavior maintained by unknown or uncontrolled sources of reinforcement. Delivery of punishment was gradually leaned while attempting to maintain low levels of SIB. Paul and Merry participated in Study 3 because results of Study 1 indicated that their hand mouthing was not maintained by social consequences.

Three to four sessions were conducted daily for each subject, 4 to 5 days per week. All sessions lasted 15 min. When the therapist delivered the punisher (20-s timeout for Paul and 15-s manual restraint for Merry), session time was stopped, and these intervals were not included in the total session time.

The effects of FR 1 punishment on SIB were first examined by exposing subjects to baseline and treatment conditions within a reversal design. After subsequently identifying an ineffective FI punishment schedule, the FR-1 schedule was reimplemented and gradually “thinned” every few sessions as long as responding remained low.

Paul

Baseline. During these sessions, Paul had continuous access to a hand-held massager. No one interacted with him.

Timeout (FR 1). Paul had continuous access to the massager; however, the therapist removed the massager for 20 s contingent on each occurrence of hand mouthing. If Paul

engaged in hand mouthing during the last 10 s of the timeout period, the interval was extended until he had not engaged in hand mouthing for 10 s.

Timeout (FI 5 min). The timeout procedure was implemented as described in the previous section. However, the therapist removed the massager for 20 s contingent on the first occurrence of hand mouthing after 5 min had elapsed since the last timeout (or the start of the session). If Paul was already engaging in hand mouthing at the end of the 5-min interval, the therapist immediately removed the massager for 20 s. Thus, a maximum of three time-out periods was possible during these sessions.

Timeout (fading). During this phase, delivery of timeout was faded from FR 1 to FI 5 min. Starting with an initial INT schedule of FI 30 s, the interval was lengthened by 30 s every time levels of hand mouthing were equal to or below 10% of the intervals for four consecutive sessions.

Merry

For all conditions, Merry was removed from her wheelchair and placed in a regular chair prior to the start of the session.

Baseline. These sessions were identical to the Alone sessions of Merry's functional analysis.

Contingent restraint (FR 1). No one interacted with Merry during these sessions; however, contingent on each occurrence of hand mouthing, the therapist removed Merry's hand from her mouth and held both arms to her sides for 15 s, using the minimum force necessary to keep Merry's hands stationary near her lap.

Contingent restraint (FI 2 min). Contingent restraint was implemented as described in the previous section. However, the therapist implemented the restraint procedure contingent on the first occurrence of hand mouthing after 2 min had elapsed since the last restraint delivery (or the start of the session). If Merry was already engaging in hand mouthing at the end of the 2-min interval, the therapist immediately implemented the

restraint contingency. Thus, contingent restraint could be delivered a maximum of seven times during each session.

Contingent restraint (fading). During this phase, delivery of contingent restraint was faded from FR 1 to FI 2 min. The initial INT schedule was FI 15 s, and the interval was lengthened by 15 s or 5 s (see results) when levels of hand mouthing were equal to or below 10% of the intervals for five consecutive sessions.

Results

Results of Study 3 are shown in Figures 8 and 9 and are summarized in Table 2. Results for Paul are displayed in Figure 8. Paul engaged in moderate but variable levels of hand mouthing during baseline ($M = 33\%$). Treatment with timeout (FR 1) produced an immediate reduction in the behavior to low levels ($M = 4.2\%$). With the removal of timeout in the next phase, Paul's hand mouthing rapidly increased and maintained at a moderate level ($M = 44.2\%$). These findings indicated that an FR-1 schedule of timeout was effective in treating Paul's hand mouthing.

When an FI 5-min schedule was then implemented, hand mouthing decreased and then increased again to baseline levels ($M = 26\%$). The reintroduction of timeout (FR 1) again produced a reduction in hand mouthing ($M = 4.4\%$), and the behavior remained low as the timeout schedule was gradually leaned to FI 5 min. Across the 57 sessions of the schedule fade, hand mouthing occurred in an average of 3.4% of the intervals. Hand mouthing also remained low when Paul was exposed to the final FI 5-min schedule of timeout ($M = 2.4\%$), suggesting that the fading procedure increased the efficacy of an initially ineffective INT punishment schedule.

Results for Merry are shown in Figure 9. During baseline, levels of hand mouthing were variable and moderate ($M = 46\%$). Treatment with contingent restraint (FR 1) resulted in an immediate decrease in SIB to low levels ($M = 6.6\%$). Hand mouthing then

Figure 8. Percentage of intervals of hand mouthing for Paul across sessions in Study 3.

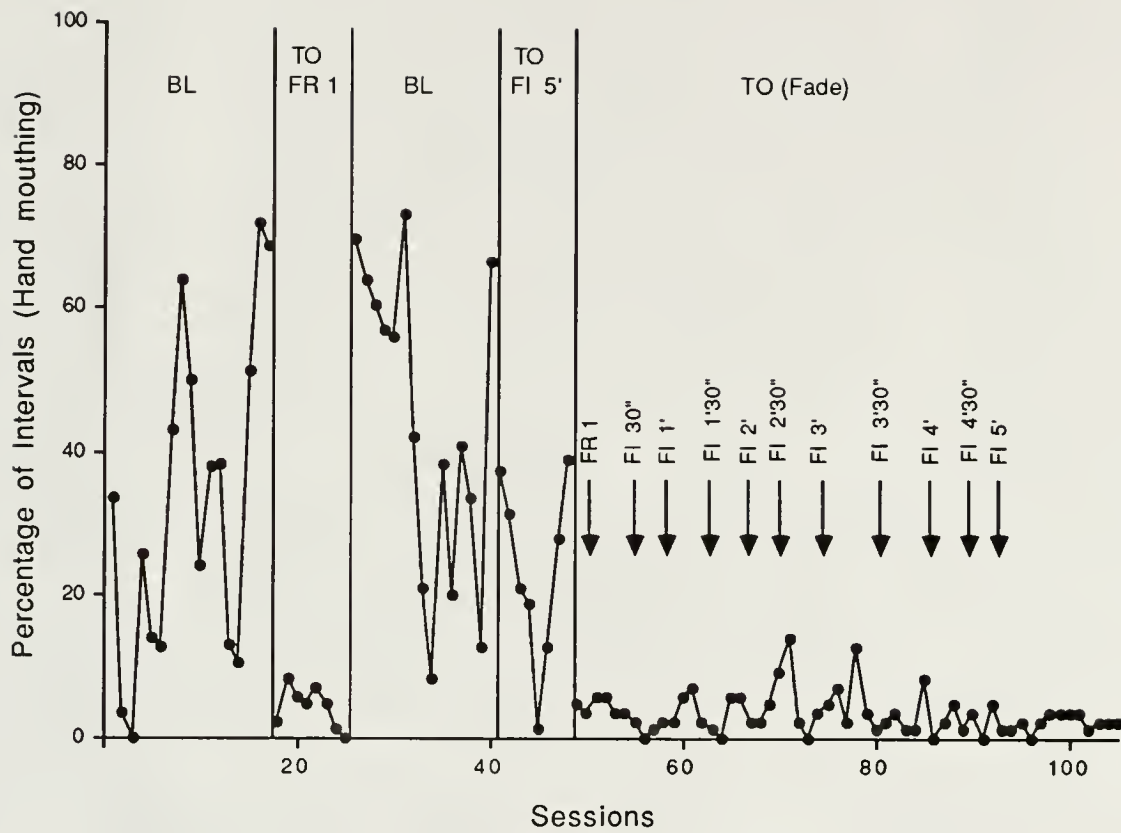
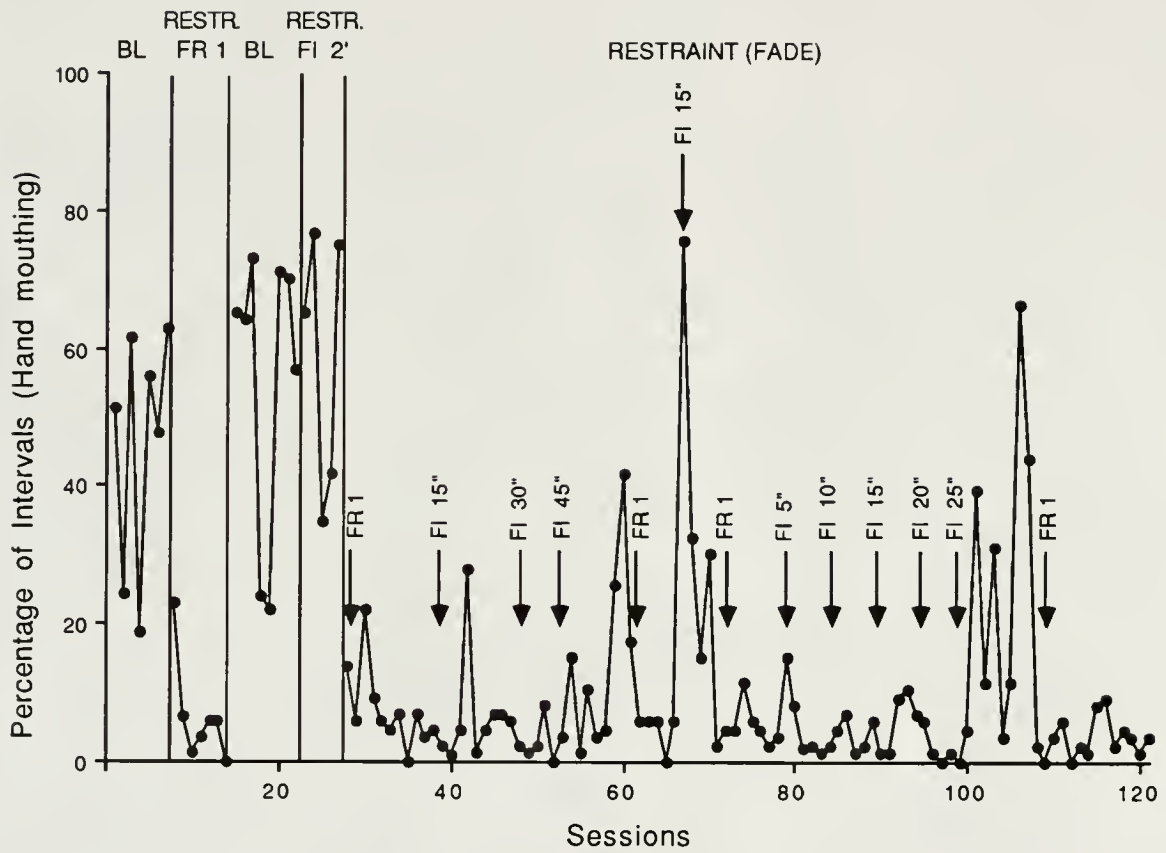
Paul

Figure 9. Percentage of intervals of hand mouthing for Merry across sessions in Study 3.

Merry



increased and maintained at moderate levels with the return to baseline ($M = 55.7\%$). These findings indicated that contingent restraint (FR 1) was effective in treating Merry's hand mouthing.

When contingent restraint (FI 2 min) was implemented, levels of hand mouthing were similar to those in baseline ($M = 58.7\%$), and the reintroduction of contingent restraint (FR 1) again produced significant decreases in SIB ($M = 7.9\%$). Hand mouthing remained relatively low as the schedule was leaned to FI 45 s, under which responding became more variable and increased to baseline levels. FR 1 was then implemented to re-establish treatment effects before attempting to fade a second time. Hand mouthing decreased to low levels under FR 1; however, behavior increased dramatically during the first session of INT punishment (FI 15 s) and maintained at moderate levels for the next few sessions. As a result, FR 1 was again introduced before leaning the schedule more gradually (i.e., using 5-s increments). During the third attempt to fade the schedule, levels of hand mouthing remained low until FI 25 s, when responding became more variable and maintained at moderate levels across 7 sessions. These findings suggested that contingent restraint would not effectively treat Merry's hand mouthing unless nearly every response was followed by punishment. Instead of attempting to lean the schedule any further, FR 1 was reimplemented and Merry's participation in the study was terminated. Across the final 14 sessions with FR 1, levels of hand mouthing remained low ($M = 3.3\%$).

Results showed that FR-1 punishment was effective for both subjects. Paul's hand mouthing remained unchanged throughout a lengthy fading procedure, whereas Merry's hand mouthing increased when the punishment schedule was leaned slightly. A closer examination of the subjects' response patterns during punishment could provide at least one explanation for these discrepant outcomes. Under the FI schedules, occurrences of hand mouthing were not punished when their interresponse times (IRTs) were relatively

short (i.e., shorter than the interval used in the FI schedule). If Merry's responses often immediately followed delivery of punishment, FI punishment schedules (and hence the schedule fade) probably would be ineffective. That is, levels of hand mouthing would likely increase as the schedule interval was lengthened, and the delivery of manual restraint eventually could function as a discriminative stimulus for the temporary discontinuation of the punishment contingency.

Data on the relative frequency (or distribution) of various IRTs from selected treatment sessions were compared for the two subjects. Specifically, amount of time that elapsed since the previous punishment delivery (or the start of the session if no punisher had been delivered) was calculated for each occurrence of hand mouthing. Data from the last 5 sessions of FR 1 (immediately prior to the start of the schedule fade) and from the last 5 treatment sessions were included in the analysis. These data are summarized in Table 2. The table shows the proportion of responses that followed the previous punishment delivery (or start of the session) by specific amounts of time for Paul (left side) and Merry (right side). Results for the last 5 sessions of FR 1 (sessions 50-54 for Paul and 33-37 for Merry) are displayed in the second and fourth columns. Results generally showed that a large proportion of Merry's hand mouthing was distributed among the short IRTs (i.e., 0 s to 2 min) compared to Paul's hand mouthing. In fact, a relatively large proportion of Merry's responses (37%) occurred within the first 20 s of the previous punishment delivery. By contrast, a small percentage of Paul's hand mouthing (10%) had such short IRTs.

Results for the last 5 treatment sessions (sessions 101-105 for Paul and 117-121 for Merry) are shown in the third and fifth columns. When compared to the findings from the first 5 FR-1 sessions, these data show changes in the distribution of the IRTs following exposure to the schedule fade. The distribution of Merry's IRTs shifted somewhat toward the shorter values (0 s to 2 min). By contrast, Paul's distribution of

Table 2
Proportion of Responses that Followed Punishment Delivery
Within Specified Time Periods (in seconds)

	<u>Paul</u>		<u>Merry</u>	
<u>Latency Period</u>	<u>Last Five FR-1 Sessions</u>	<u>Last Five Treatment Sessions</u>	<u>Last Five FR-1 Sessions</u>	<u>Last Five Treatment Sessions</u>
0-20	.10	.18	.37	.31
21-40	.16	0	.10	.23
41-60	.05	0	.10	.08
61-120	.26	.09	.21	.23
121-180	.05	.09	.10	0
181-240	.10	.09	.05	0
241-300	.05	0	0	0
300+	.21	.54	.05	.15

IRTs generally shifted toward the larger values. As a result, the majority of Merry's hand mouthing (85%) occurred within 2 min of the previous punishment delivery, whereas the majority of Paul's hand mouthing (54%) followed the previous timeout by more than 5 min.

Discussion

This study examined the efficacy of gradually fading delivery of punishment with two individuals who engaged in chronic hand mouthing not maintained by social consequences. Results for one subject (Paul) demonstrated that an FI schedule of punishment could be leaned while maintaining low levels of responding. Findings for Paul further suggested that the fading procedure increased the effectiveness of an INT schedule that had previously failed to suppress hand mouthing to low levels. Results for the other subject (Merry) indicated that any useful FI punishment schedule probably would be ineffective, despite repeated attempts to gradually lean the schedule beyond FR 1.

These conflicting outcomes were not anticipated prior to the fading procedure because a continuous schedule of punishment was equally effective for both subjects. Results showed that FR-1 punishment with either contingent timeout (Paul) or manual restraint (Merry) successfully treated hand mouthing. However, a closer examination of these data indicated that Merry's hand mouthing (when it did occur) often immediately followed the delivery of punishment or the start of the session, a pattern of responding that might jeopardize the effectiveness of FI punishment schedules. Thus, an analysis of an individual's IRTs under FR-1 punishment may indicate if delivery of punishment can be successfully leaned using FI schedules.

Results for Merry suggested that her behavior also became more sensitive to the FI punishment contingencies with repeated attempts to lean the schedule. Initially, hand

mouthings remained low until the FI 45-s schedule. During the second attempt to fade delivery of punishment, levels of hand mouthing escalated under the shortest FI schedule (FI 15 s). When the fading procedure was then introduced more gradually (i.e., the interval was lengthened in 5-s increments), the punishment schedule could not be leaned beyond FI 20 s. The shift toward shorter IRTs under FR 1 at the conclusion of the experiment (as shown in Table 2) also suggests that Merry's hand mouthing had become more sensitive to the FI punishment contingencies. Under FI schedules, responses with lengthy IRTs (i.e., those longer than the interval used in the FI schedule) are selectively punished. As a result, the frequency of responses with relatively short IRTs will likely increase (cf. Galbicka & Branch, 1981). Eventually, delivery of punishment also could function as a discriminative stimulus for "punishment-free" periods, leading to a gradual overall increase in responding under FI punishment. Basic studies on FI punishment schedules have shown that response rates often are highest immediately following the delivery of punishment and decelerate across the schedule interval (e.g., Azrin, 1956). During FI sessions with high levels of responding, Merry typically would hand mouth continuously throughout the interval, but response patterns occasionally resembled those obtained in basic studies.

On the other hand, Paul's hand mouthing remained low across the schedule fade, and an analysis of response patterns during the final FI-5 min sessions showed that the IRTs were still fairly lengthy. Findings indicated that about 50% of his responses followed the previous punishment delivery by greater than 5 min. As a result, the FI-5 min schedule actually resembled an FR-2 schedule. Despite extended exposure to FI punishment, Paul's behavior remained insensitive to the specific FI contingencies (i.e., he failed to learn that responses would not be punished if they occurred during a prespecified period following each timeout). The process(es) responsible for this outcome are not clear. During the fading procedure, certain features of the treatment

setting (e.g., presence of the massager or therapist) may have been established as powerful discriminative stimuli for punishment. As such, these stimuli would set the occasion for low levels of hand mouthing, and Paul's behavior would rarely contact the absence of the punishment contingency. In this situation, the long-term effectiveness of INT punishment might depend on tightly controlled treatment conditions, which are not typical in clinical settings.

A number of variables could have influenced the efficacy of INT punishment for Merry. For example, a different type of punishing stimulus might have produced lengthier IRTs under FR 1 or competed more successfully with the ongoing schedule of reinforcement for hand mouthing. Cipani et al. (1991) compared the effects of continuous and INT schedules of punishment using two different punishment procedures and found that both FR-1 and VR-4 schedules of contingent lemon juice effectively suppressed the stereotypic behaviors of an autistic child. On the other hand, VR 4 was not as effective as FR 1 when overcorrection (contingent manual guidance) was implemented during a different phase.

A different type of punishment schedule also may have increased the likelihood of a successful schedule fade for Merry. For example, Azrin (1956) found that a VI schedule of contingent electric shock produced lower levels of key pecking in pigeons than an FI schedule. Under VI schedules, the delivery of punishment is somewhat unpredictable and thus less likely to be established as a discriminative stimulus for the temporary discontinuation of punishment. For Merry, FI schedules may have been ineffective because she often engaged in hand mouthing soon after the delivery of manual restraint (i.e., within 20 s). Some of these responses would have been punished if VI schedules had been implemented throughout the fading procedure.

Alternatively, FI punishment schedules may have been effective for Merry following lengthier exposure to FR 1. The fading procedure was initiated when hand mouthing

was low for five consecutive sessions. However, continued exposure to FR 1 (e.g., for 20 to 30 sessions) may have altered the distribution of IRTs or increased the efficacy of INT punishment in some other manner. In fact, the criterion for attempting to lean the schedule could have been based on the pattern of IRTs rather than on overall level of responding. For example, the FR-1 schedule could have been changed for Merry when 50% or more of the IRTs were greater than 2 min for 5 consecutive sessions. In addition, all subsequent steps in the fading procedure could have been based on the current distribution of IRTs, a procedure similar to that used in Barton et al. (1987). Such a strategy would ensure that a large proportion of responses is punished even as the schedule is gradually leaned.

Results for Merry also may be specific to behavior that continues to receive reinforcement during treatment. An extinction component would likely increase the efficacy of INT punishment or, at the least, enhance the fading procedure (cf. Azrin & Holz, 1961). Although no studies have compared the effects of INT punishment with and without extinction, previous studies obtaining significant reduction of problem behavior with INT punishment likely included an extinction component in the treatment program (see Iwata, Pace, Cowdery et al., 1994, for a discussion of this issue). If reinforcement for hand mouthing had been eliminated in some manner, the punishment schedule may have been leaned successfully for both subjects. In fact, the initial INT punishment schedules (FI 5 min for Paul and FI 2 min for Merry) might have been effective prior to the fading procedure. However, the primary purpose of this study was to examine the use of INT punishment when treatment with extinction is impractical (as in the case of behavior maintained by automatic reinforcement; cf. Vollmer & Iwata, 1993). Treatment procedures involving INT punishment schedules generally are unnecessary when the response-reinforcer relationship can be terminated.

Although results for Paul indicated that punishment schedules can be leaned in the absence of extinction, additional research should examine factors that might increase the

efficacy of INT punishment (e.g., different fading procedures, punishing stimuli, or schedules). In addition, the utility of the schedule fade and its role in altering the effectiveness of INT punishment should be established. For example, the FI 5-min schedule might have reduced Paul's hand mouthing following lengthy exposure to FR-1 punishment (instead of the gradual fade) or following a more rapid fading process (e.g., using 2-min rather than 30-s increments). The generality of the findings for Paul also are somewhat limited because the procedure was implemented under tightly controlled conditions rather than in the natural environment. Results suggest that INT punishment may be effective in applied settings if all caregivers systematically learn the schedule in all relevant contexts (work, home, school, etc.). However, additional studies must examine the utility of this relatively complex strategy. Long-term maintenance of treatment under INT punishment also must be assessed in further research.

Caregivers often may reject the use of procedures such as timeout and contingent manual restraint on the grounds that they are relatively intrusive and too time-consuming to implement (O'Brien & Karsh, 1990). Nevertheless, punishment procedures may be essential when the reinforcers maintaining behavior cannot be identified or controlled, or when substitute reinforcers cannot be found. In this study, timeout was used infrequently with Paul after the punishment schedule was leaned to FI-5 min, and the schedule permitted discontinuous monitoring of behavior. Such an outcome has important implications for the acceptability of punishment in applied settings.

GENERAL DISCUSSION

The current series of experiments examined the effects of INT schedules of reinforcement and punishment on the treatment of problem behavior. Results indicated that these schedules can influence responding in important ways and suggested various strategies for the use of intermittent contingencies in applied settings. These findings are noteworthy because problem behavior often is exposed to INT schedules in the natural environment. Caregivers and teachers rarely have the time or resources to respond to each occurrence of behavior. As a result, most behavior disorders are maintained on INT reinforcement schedules prior to treatment (with the possible exception of behaviors that pose immediate danger to the individual or others), and behavior often may be exposed to INT punishment schedules when the treatment program involves a punishment procedure.

Study 2 compared the effects of FR-1 and INT reinforcement schedules on rates of problem behavior prior to treatment and on the course of responding during extinction. Results demonstrated that INT schedules were associated with higher rates of problem behavior during baseline conditions, a finding that replicates those of previous studies examining the effects of ratio schedules on response rate (e.g., De Luca & Holborn, 1992; Lovaas, Freitag, Gold, & Kassorla, 1965; Schroeder, 1972; Stephens, Pear, Wray, & Jackson, 1975). Responding also was higher during the initial stages of extinction following baseline with INT reinforcement. Thus, the benefits of switching from an INT to an FR-1 schedule prior to extinction were investigated with two subjects. Results suggested that the total number of responses exhibited during extinction may be

reduced if caregivers simply implement an FR-1 baseline for a short period of time prior to treatment. Although caregivers may be somewhat reluctant to implement a strategy that involves deliberate reinforcement of problem behavior, the advantages may be clear when dangerous behaviors are targeted for reduction.

Nevertheless, continuous reinforcement was not associated with a significant reduction in response persistence during extinction. In fact, robust treatment effects were obtained for all subjects following baselines with either INT or FR-1 schedules. Although this finding appears to contradict a well-established phenomenon (i.e., the PREE), results are consistent with those of basic studies using within- rather than between-subject designs (e.g., Adams et al., 1982; Flora & Pavlik, 1990). Factors responsible for the conflicting outcomes among basic studies are still relatively unclear. However, results of studies using within-subject designs may be particularly vulnerable to confounding by sequence or interaction effects.

Research findings on the PREE also are equivocal because “resistance” has been defined and measured in a variety of ways. Most studies measured resistance to extinction by calculating response rates, total number of responses, or amount of time to meet an extinction criterion. In general, these studies demonstrated greater resistance to extinction following INT than FR-1 schedules. Others have attempted to adjust for the differences in responding associated with the different baseline conditions by calculating the rate of change in responding during extinction or the proportion of baseline response rates (cf. Nevin, 1988). Results of these studies indicated that FR-1 schedules were associated with greater resistance to extinction than INT schedules. The current study provides further data showing that reinforcement schedules can produce very different outcomes, depending on the particular measure used to reflect “resistance.” These findings suggest that the relationship between reinforcement schedules and responding

during extinction is somewhat complex and that many texts and articles on application present an incomplete account of current research findings on the PREE.

Study 3 examined the effects of INT punishment schedules on rates of problem behavior. Results showed that certain INT punishment schedules will not significantly alter responding maintained by automatic reinforcement, but that these schedules can be effective following a process that involves gradually “thinning” or leaning the schedule parameters. Although the factors responsible for the efficacy of this procedure were not determined, results may have hinged on the development of powerful discriminative stimuli for punishment (e.g., presence of the therapist or massager, features of the therapy room). Behavior that is under tight stimulus control probably will be somewhat insensitive to the specific intermittent contingencies. In particular, a high proportion of responses will be punished if behavior remains low under FI schedules (resulting in a dense schedule of punishment). The role of the fading procedure in the development of such discriminative stimuli is unknown; thus, this procedure may be just one of numerous strategies for increasing the efficacy of INT punishment.

Further investigation of this procedure is warranted. The generality and reliability of the findings for Paul should be established with other subjects, punishment procedures, and INT schedules. More important, factors that might alter the outcome of schedule fading, including the distribution of IRTs prior to and during the fading process, should be directly manipulated. Although the utility of punishment as treatment for severe behavior disorders has been firmly established in the literature (Axelrod & Apsche, 1983; Matson & DiLorenzo, 1984), these findings likely depended on the consistent application of punishment procedures. As a result, the robust treatment effects demonstrated in these studies may be somewhat difficult to replicate in the natural environment. The intrusive nature of punishment per se also makes it a relatively unpopular treatment option among

caregivers and clinicians. Thus, results of Study 3 have important implications for both the efficacy and acceptability of punishment in applied settings.

The current investigation joins a surprisingly small number of applied studies examining the effects of INT reinforcement or punishment schedules. Although basic research findings indicate that INT schedules could influence the treatment of problem behavior, the clinical significance of these effects and the development of related treatment strategies should be established by conducting further studies with human behavior in applied settings.

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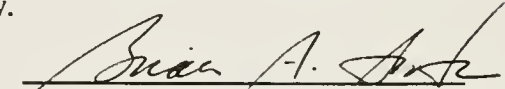
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BIOGRAPHICAL SKETCH

Dorothea C. Lerman was born in Daytona Beach, Florida, on February 16, 1966. She earned a Bachelor of Science degree in psychology from the University of Florida in April 1988. Although she took a variety of courses, Dorothea was not exposed to behavior analysis until her senior year, when she met Dr. Brian Iwata and asked him to supervise her senior thesis. As a direct result of this experience and Brian Iwata's encouragement, she decided to enter the field of applied behavior analysis. Dorothea worked for two years as a program manager at a sheltered workshop for individuals with developmental disabilities before enrolling at the University of Florida as a graduate student in psychology (experimental analysis of behavior) in 1990. She has participated in research activities throughout graduate school and served as a teaching assistant and instructor. Dorothea's research has emphasized analysis and treatment of severe behavior disorders in individuals with developmental disabilities. After graduation, she plans to pursue a career in behavior analysis, including teaching and research.

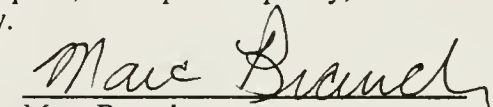
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Brian A. Iwata, Chairperson
Professor of Psychology


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Timothy D. Hackenberg
Assistant Professor of Psychology

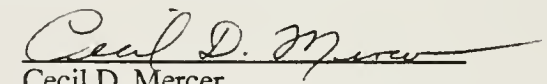
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Marc Branch
Professor of Psychology

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Shari A. Ellis
Assistant Professor of Psychology

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.


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This dissertation was submitted to the Graduate Faculty of the Department of Psychology in the College of Liberal Arts and Sciences and to the Graduate School and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

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